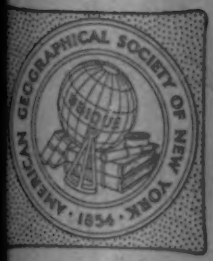
PERIODICAL ROOM
GENERAL LIBRARY
UNIV. OF MICH.

APR 6 1928

GEOGRAPHICAL REVIEW

PUBLISHED BY

THE AMERICAN GEOGRAPHICAL SOCIETY
OF NEW YORK



APRIL
1928

OUR CONTRIBUTORS

DR. BAIN is secretary of the American Institute of Mining and Metallurgical Engineers and a recognized authority on problems of mineral resources. His important study of "Ores and Industry in the Far East" (1927) was selected by the Council on Foreign Relations as the first of its Research Publications.

MR. MUNDAY is a member of the British Columbia Mountaineering Club and of the Alpine Club of Canada. He has explored a greater area of the Coast Range of British Columbia than any other climber, his later work in the region having been done in conjunction with his wife.

MR. RICKETSON is in charge of the excavations now being carried out at Uaxactun, Guatemala, by the Carnegie Institution of Washington, for whom he has worked since 1921. His work has taken him across the peninsula of Yucatan from Belize to Frontera, up the east coast to Tulum, and into the Petén District six times. During 1924 he excavated at Baking Pot, British Honduras, and in 1925 was at Chichen Itza, Yucatan. He has also worked in the Southwest for the National Geographic Society and for the Peabody Museum of Harvard University.

PROFESSOR JEFFERSON is professor of geography at the State Normal College, Ypsilanti, Mich. His varied geographical studies include especially investigations into population distribution and climatology in its human aspects. Among his writings are "Principles of Geography" (1926); "Man in Europe" (1924 and 1926); and in the *American Geographical Society's Research Series*, "Recent Colonization in Chile" and "The Rainfall of Chile" (1921), and "Peopling the Argentine Pampa" (1926).

DR. BIGELOW is research curator of zoölogy of the Museum of Comparative Zoölogy, Cambridge, Mass. He is chairman of the North American Committee on Fisheries Investigations and scientific advisor to the International Ice Patrol. For many years he has been engaged in an oceanographic and biologic survey of the Gulf of Maine, a memoir on which has recently appeared as Vol. 40 of the *Bulletin of the Bureau of Fisheries*.

DR. BLANCHARD is professor of geography in the University of Illinois. He is the author of several local studies and is now working on a series of papers in the economic geography of Europe, based in part on field work.

DR. DIXEY is government geologist to the Nyasaland Protectorate. He previously held a similar position in Sierra Leone. In both countries his work has included physiographic and economic investigations. "The Physiography of Sierra Leone" appeared in the *Geographical Journal*, Vol. 60, 1922. To the *Geographical Review* he contributed "The Mlanje Mountains of Nyasaland" (October, 1927).

DR. WOLFE is professor of economics in the Ohio State University. He has studied population problems and taught courses dealing with population for many years. His recent writings in the field include "The Optimum Size of Population," in "Population Problems," edited by L. I. Dublin, 1926, and "Is There a Biological Law of Population Growth?", *Quarterly Journal of Economics*, August, 1927.

MR. FISHER is principal of the American Boys' School, Hamadan, Persia, the Ecbatana of ancient times.

MISS WARTHIN is a member of the staff of the American Geographical Society.

THE GEOGRAPHICAL REVIEW

CONTENTS FOR APRIL, 1928

	PAGE
The Third Kingdom: Some Reflections on Our Mineral Heritage *By H. Foster Bain*	177
Explorations in the Coast Range of British Columbia *By W. A. Don Munday*	196
Astronomical Observatories in the Maya Area *By Oliver Ricketson, Jr.*	215
An American Colony in Brazil *By Mark Jefferson*	226
Exploration in the Waters of the Gulf of Maine *By Henry B. Bigelow*	232
White Coal in Italian Industry *By W. O. Blanchard*	261
The Distribution of Population in Nyasaland *By F. Dixey*	274
Some Population Gradients in the United States *By A. B. Wolfe*	291
Irrigation Systems of Persia *By Commodore B. Fisher*	302
Transportation Developments in Central Africa *By M. Warthin*	307
Twenty-fourth Annual Meeting of the Association of American Geographers *By R. M. Brown*	310
American Geographical Society	313
Geographical Record (*listed on the next page*)	321
Geographical Reviews (*listed on the next page*)	336
Correspondence	351

The Society is not responsible for the opinions or the statements of writers in the Review

PUBLISHED QUARTERLY BY THE AMERICAN GEOGRAPHICAL SOCIETY
BROADWAY AT 156TH STREET, NEW YORK, N. Y.

Price, $1.25 a number Five dollars a year

Entered as second-class matter, January 22, 1916, at the Post Office at New York, N. Y., under the Act of August 24, 1912.

Acceptance for mailing at special rate of postage provided for in section 1103. Act of October 3, 1917, authorized on July 30, 1918.

GEOGRAPHICAL RECORD

NORTH AMERICA

The Winter Maintenance of Highway Transportation 321

Mt. Multnomah, a Cone-Filled Caldera of the Cascade Range. *By W. M. Davis* .. 322

A Soil Map of Florida 322

SOUTH AMERICA

The Economic Status of British Guiana and Its Improvement 323

Snowstorms in the Central Valley of Chile 324

EUROPE

The Present Situation and Trends of the Mineral Industry in Upper Silesia. *By E. Muriel Poggi* 325

Hydro-electric Industry and Labor Problems in the French Alps 327

Natural Preserves and Natural Parks in Fenno-Scandia. *By Eugene Van Cleef* .. 328

AFRICA

The Port of Alexandria 329

Natal as a Source of Tanning Material 330

AUSTRALASIA AND OCEANIA

Land Utilization in Hawaii 330

Estimates of Marine and Fluvial Erosion in Hawaii. *By Kirk Bryan* 332

GEOGRAPHICAL NEWS

An Announcement Regarding the New Journal of Abstracts in the Social Sciences. *By F. Stuart Chapin* 333

OBITUARY

Major General George Washington Goethals 335

GEOGRAPHICAL REVIEWS

T. A. JOYCE. Report on the Investigations at Lubaantun, British Honduras, in 1926; THOMAS GANN. In an Unknown Land; Mystery Cities; Ancient Cities and Modern Tribes; GREGORY MASON. Silver Cities of Yucatan;—Tribes and Temples: A Record of the Expedition to Middle America Conducted by the Tulane University of Louisiana in 1925; MANUEL GAMIO. Cultural Evolution in Guatemala and its Geographic and Historic Handicaps; S. K. LOTHROP. Pottery of Costa Rica and Nicaragua; Stone Sculptures from the Finca Arevalo, Guatemala; Pottery Types and Their Sequence in El Salvador; Tulum: An Archaeological Study of the East Coast of Yucatan; S. G. MORLEY. Investigation in [Middle American] Archaeology; A. M. TOZZER. Time and American Archaeology. *By George C. Vaillant* 336

EMERSON D. FITE AND ARCHIBALD FREEMAN. A Book of Old Maps Delineating American History from the Earliest Days Down to the Close of the Revolutionary War 339

ARTHUR L. HUMPHREYS. Old Decorative Maps and Charts 339

H. R. WAGNER. Sir Francis Drake's Voyage Around the World 340

J. W. ROBERTSON. Francis Drake and Other Early Explorers Along the Pacific Coast 340

—Sir Francis Drake's Voyage Round the World 1577–1580: Two Contemporary Maps 340

N. M. PENZER, edit. The World Encompassed and Analogous Contemporary Documents Concerning Sir Francis Drake's Circumnavigation of the World 340

R. G. ALBION. Forests and Sea Power: The Timber Problem of the Royal Navy 1652–1862. *By Lawrence S. Mayo* 341

S. M. SHIROKOGOROFF. Anthropology of Northern China; Who are the Northern Chinese?; Anthropology of Eastern China and Kwangtung Province. *By C. W. Bishop* 343

HERBERT LOUIS. Albanien: Eine Landeskunde vornehmlich auf Grund eigener Reisen. *By Alan G. Ogilvie* 344

D. P. BARROWS. Berbers and Blacks: Impressions of Morocco, Timbuktu, and the Western Sudan 346

OTTO JESSEN. Die Strasse von Gibraltar 347

ERICH VON DRYGALSKI. Ozean und Antarktis. *By H. A. Marmer* 348

K. HESSEN. Gezeiten- und strombeobachtungen auf der Winterstation des "Gauss" 1902–03. *By H. A. Marmer* .. 348

MARIA RECKNAGEL. Die Städte und Märkte des Bayerischen Donaugebiets. *By H. J. Fleure* 349

EDUARD IMHOF. Siedelungsgrundriss-Formen und ihre Generalisierung im Kartenbilde. *By H. J. Fleure* 349

JOSEPH GANTNER. Die Schweizer Stadt. *By H. J. Fleure* 349

AMERICAN GEOGRAPHICAL SOCIETY PUBLICATIONS
PARTIAL LIST

A booklet describing the aims and activities of the Society may be obtained upon request

Bulletin of **the American Geographical Society, 1852–1915.** Fifty-one volumes. Known as *Bulletin* (1852–1856), *Proceedings* (1862–1864), *Journal* (1859–1860, 1870) *of the American Geographical and Statistical Society*, and as *Bulletin* (designated *Journal*, however, on title page of bound volumes to 1900) *of the American Geographical Society* (1872–1915). Generally quarterly to 1903; monthly, 1904–1915. The volumes for the following years are available at $1.00 each: 1871, 1872, 1874, 1876, 1878–1905 inclusive, 1908, 1915. A set of the *Bulletin* from 1859 (complete except for four volumes that lack individual numbers) may be obtained for $150.00.

Index to the **Bulletin of the American Geographical Society, 1852–1915.** By ARTHUR A. BROOKS. With an historical and bibliographical note and a table showing the arrangement and composition of the series. xi and 242 pp. $2.00.

The **Geographical Review.** Vols. 1–18, 1916 to date. Successor to the *Bulletin of the American Geographical Society*. Monthly, 1916–1920; quarterly since 1921. Monthly numbers, 50 cents; quarterly numbers, $1.25; unbound volumes, 1916–1920 (two a year), $2.50; from 1921 (one a year), $5.00.

Index to the **Geographical Review, Vols. I–XV, 1916–1925.** By ARTHUR A. BROOKS. iii and 432 pp. 1926. $4.50, unbound; $5.25, bound.

China: **Land of Famine.** By WALTER H. MALLORY. With a Foreword by DR. JOHN H. FINLEY, President of the American Geographical Society. With 91 photographs and 12 maps. xvi and 199 pp. *Special Publication No. 6.* 1926. $4.00.

Problems of **Polar Research.** By 31 AUTHORS. 479 pp.; 96 maps, diagrams, and photographs. *Special Publication No. 7*, 1928. $5.00.

The **Geography of the Polar Regions.** By OTTO NORDENSKJÖLD and LUDWIG MECKING. 370 pp.; 135 maps, diagrams, and photographs. *Special Publication No. 8*, 1928. $4.00.

The **Coral Reef Problem.** By W. M. DAVIS. 596 pp.; 227 maps, diagrams, and photographs. *Special Publication No. 9*, 1928. $6.00.

Bering's Voyages: An Account of the Efforts of the Russians to Determine the Relation of Asia and America. By F. A. GOLDER. Vol. 1: **The Log Books and Official Reports of the First and Second Expeditions, 1725–1730 and 1733–1742.** With a chart of the second voyage, by Captain E. P. BERTHOLF. Vol. 2: **G. W. Steller's Journal of His Sea Voyage from Kamchatka to America on the Second Expedition.** Translated and edited by F. A. GOLDER and LEONHARD STEJNEGER. *Research Series Nos. 1 (1922) and 2 (1925).* The volumes will not be sold separately. $8.00.

The **Vegetation and Soils of Africa.** By H. L. SHANTZ and C. F. MARBUT. With a section on land classification by the joint authors and a note on a rainfall map of Africa by J. B. KINCER. With 1 text map, 49 photographs, and a separate case of two maps (in color) 1:10,000,000, each with inset, 1:25,000,000, showing vegetation (on inset: soils) and land classification (on inset: annual rainfall). x and 263 pp. *Research Series No. 13*, 1923. $5.00.

The Geographical Lore of the Time of the Crusades: A Study in the History of Medieval Science and Tradition in Western Europe. By JOHN KIRTLAND WRIGHT. With 10 maps, mainly facsimiles of medieval maps, and 2 diagrams. xxi and 563 pp. *Research Series No. 15*, 1924. $5.00.

Peopling the Argentine Pampa. By MARK JEFFERSON. With 55 photographs, 9 maps, and 4 diagrams. viii and 211 pp. *Research Series No. 16*, 1926. $4.00.

The Last Glaciation, With Special Reference to the Ice Retreat in Northeastern North America. By ERNST ANTEVS. 292 pp.; 30 maps and diagrams and 9 separate plates. *Research Series No. 17*, 1928. $3.50.

The Northern Ḥeğâz: A Topographical Itinerary. By ALOIS MUSIL. With 66 photographs, 12 drawings, 4 plans, and 4 maps in the text; in pocket, map of the Northern Ḥeğâz, 1:500,000, in brown and black, and index map, 1:2,000,000. xii and 374 pp. *Oriental Explorations and Studies No. 1.* 1926. $7.00.

Arabia Deserta: A Topographical Itinerary. By ALOIS MUSIL. With 96 photographs, 15 drawings, 8 plans, and 1 map in text; in pocket, index map, 1:4,000,000; in map case, map of Northern Arabia, 1:1,000,000, in 4 sheets, each 52 x 49 cm.; xvii and 631 pp. *Oriental Explorations and Studies No. 2.* 1927. $8.00.

Geography of the Central Andes: A Handbook to Accompany the La Paz Sheet of the Map of South America on the Millionth Scale. By ALAN G. OGILVIE. With an introduction by ISAIAH BOWMAN. With 2 maps in color and 41 diagrams and photographs. 240 pp. *Map of Hispanic America, Publication No. 1*, 1922. $3.00 (if purchased with the La Paz map, $2.00).

Map of Hispanic America, 1:1,000,000 [15.78 miles to 1 inch], Provisional Edition, North H-11, **Baja California Norte**; North G-12, **Baja California Sur**; North F-16, **Yucatán**; North F-18, **Santiago de Cuba**; North E-18, **Kingston-Port-au-Prince**; North E-19, **Santo Domingo-San Juan**; North E-20, **Lesser Antilles North**; North D-20, **Lesser Antilles South**; North C-17, **Panamá**; North A-17, **Río Mira-Islas Galápagos**; South C-19, **Acre**; South D-19, **Puno-Río Beni**; South E-19, **La Paz**; South E-20, **Sucre**; South F-19, **Iquique**; South F-20, **Río Pilcomayo**; South G-19, **Atacama**; South I-18, **Canquenes y Islas Esporádicas**; South L-18, **Península de Tai-Tao**; South M-18, **Isla Wellington-Lago Argentino.** $2.00 each sheet.

Mapa de la Republica de Panama, 1:500,000 [7.89 miles to 1 inch] compiled from over 100 original surveys, many of them unpublished. Printed in five colors. Follows in general the scheme of the International Map of the World on the Millionth Scale, but hypsometric tints have been omitted and the provinces shown in color instead. Accepted as official map by the government of Panama. 33 x 63 inches. 1926. $3.00.

The Leardo Map of the World of 1452 or 1453. Colored reproduction (measuring 28⅝ x 23½ inches, printed on sheet 35 x 30 inches) of map in the collections of the American Geographical Society. Accompanied by volume containing text by JOHN KIRTLAND WRIGHT describing the original map and a note by A. B. HOEN on the method of reproduction, with 3 photographs and 7 maps, viii and 90 pp. *Library Series No. 4.* 1927. $15.00 ($2.00 for text alone).

Separate Maps published in the *Geographical Review* and the *Bulletin of the American Geographical Society*, the majority in color. 25 cents each. A list will be sent upon request.

THE
GEOGRAPHICAL REVIEW

VOL. XVIII APRIL, 1928 NO. 2

THE THIRD KINGDOM

SOME REFLECTIONS ON OUR MINERAL HERITAGE

H. Foster Bain

MAN and the earth on which he lives have been the subject of study by geographers since the science of geography began, but heretofore attention has been concentrated mainly upon the earth as a surface over which man roams, a platform or stage upon which he acts his rôle. Far less consideration has been given to the earth beneath, the materials out of which it is made, the character, qualities, and distribution below the surface of these materials, all of which enter into and condition man's life and development, mightily so in these modern days. In discussing the materials with which he has worked the plant and animal kingdoms have received the major attention, but there are signs that the third kingdom is coming into its own.[1] In the words of Professor C. K. Leith addressing the Royal Institute on International Affairs a short time ago:

> Mineral resources constitute a factor in our physical environment which is being rapidly brought into prominence by the multiplying demand and the growing dependence of modern civilisation upon mineral resources. Up to comparatively recent times this environmental factor was regarded as of only incidental importance. It now figures largely in the consciousness of nations.[2]

The plant and animal kingdoms yield man many things essential to his life and happiness, but these are ephemeral. The world feeds itself from year to year on food produced mainly within twelve months of the eating. Continuous supply and continuous consumption go on together, and an accumulated stock of food for a long future is

[1] Compare the opening pages of Shaler's "Man and the Earth" and the exceptional treatment accorded minerals in Brunhes' "La géographie humaine."

[2] C. K. Leith: Mineral Resources in Certain International Relations, *Journ. Royal Inst. of Internatl. Affairs*, Vol. 5, 1926, pp. 154–159.

Copyright, 1928, by the American Geographical Society of New York

unthinkable. Past ages have handed down to us no food, only knowledge of foods. So, too, largely of clothing. The whole stock of cloth and leather we have inherited from the past would not clothe one small nation today.

Compare the mineral kingdom: go to any great museum, housed, as it happens, in a steel and stone structure with tile floors, glass windows, and metal plumbing, heated and lighted by burning coal, a structure built to last decades and probably centuries; in such a building you may see the actual marble statues that once stood in Athens and touch the coins that circulated in Rome or Carthage. The arms of early Japan, ornaments and household utensils of Chinese who lived dim centuries ago, relics of other peoples and civilizations of the long past are all there; and all of them that is preserved for us is the part that is wrought in or on minerals. The ideas and philosophy of the past we have only in part. How dark the history of Babylonia without her cuneiform tablets: what a ray of light was shed by a single Egyptian stele! Writings on paper and parchment have left us comparatively scant record, and a large part of it has come down through the ages only because copied and recopied, with how much loss and emendation scholars can never be quite certain. Our tangible heritage of the long past is almost exclusively in the form of mineral products, and we inherit so little from the ages because early peoples used minerals so sparingly.

What we pass on to the future of goods will necessarily be also in minerals. Today, the accumulated wealth of mankind is almost entirely in that form. Food is eaten or decays, cloth wears out or rots, wood remains serviceable but a few years; but roads, bridges, and buildings of stone, brick, cement, or steel are usable for centuries. Service is still held regularly in great stone cathedrals built in the Middle Ages; and parts of the old Imperial roads of China along which Marco Polo rode, bridges he crossed seven hundred years ago, are still in daily use.

The Indefinitely Increasing Demand on the Mineral Kingdom

The present is a world period of great prosperity and wealth. Man is richer than ever before in history, and the more "civilized" he is the richer he is. The more he has conquered nature and set her to work the more she has rewarded him. He eats perhaps little more than in the past but more surely and more regularly, and he enjoys greater variety. Beyond what he can consume a surplus of food means nothing to a man, whatever trading value it may have to an individual or nation. There is an easily reached limit beyond which no man consumes food, and problems of food supply are less

important now than before minerals gave man command over distance. Mark Jefferson was right when he pointed out[3] that the mechanical and industrial age had relegated food to a subordinate place among the objects for which men labor. "Hunger," he said, "has become rare in the world. It is difficult for it to survive the glare of publicity, in the abundant stores of food and the speed of transportation."[4]

A limit, too, exists as to the amount of clothing that may be worn. Quantitatively a saturation point for textiles is easily to be foreseen. After that quality and style competition alone remain, and in Western Europe and America we already are well along in that stage. The hope of the cotton weavers for increased demand rests in the proverbial lengthening of the Chinaman's shirt tail. They already are losing ground to silk and rayon, and the corduroy weavers were saved from extinction only by the demand for upholstery in automobiles.

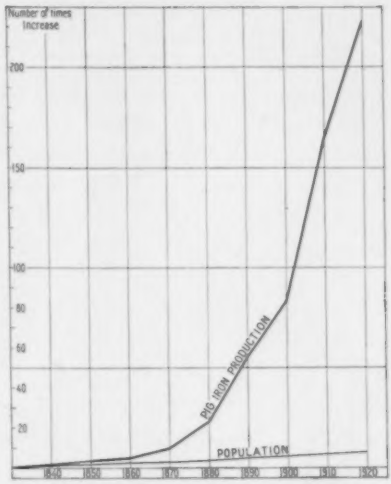


FIG. 1—Increase of pig iron production and of population in the United States between 1840 and 1920.

When, however, one turns to other of man's wants—housing, transportation, tools, and goods in general—there is no known limit, and the great economic discovery of the century has been the fact that increased consumption of all these can be stimulated, so far as we now know, almost indefinitely. Consumption of such goods is limited only by desire and purchasing power. The former can be roused while the latter increases *pari passu* with consumption through distribution of increased wages and dividends. For present discussion the significant fact is that production of all these goods is mainly dependent upon minerals either in the form of raw materials, as fuels, or as tools; and fuels and tools are equally essential to large production of food and clothing. There is no known limit to the demand we may come to make on the mineral kingdom, and the increased demand is not measured by mere growth of population. Per capita consumption of minerals in the Western countries through the last half century has increased at a rate which when plotted resembles a mountain slope, while the population curve is rather that of the playa before the mountains (Fig. 1). No longer is life so simple, so dependent on grass and moving herds, so free from impedimenta

[3] Mark Jefferson: Looking Back at Malthus, *Geogr. Rev.*, Vol. 15, 1925, pp. 177–189; reference on p. 184.

[4] *Ibid.*, p. 186.

that whole peoples may, as did the Mongols, sweep a quarter of the way around the world. Think, by way of contrast, what a task it would be now to move the German nation, with its mines, mills, smelters, railways, buildings, and all its material equipment into Mongolia. It would clearly be impossible, nor does Mongolia contain the resources to sustain such a civilization even if by miracle the people were planted there. Modern peoples are molded by their environment as were ancient peoples; but new factors have come in, and of these the most important is their necessity for enormous quantities of minerals.

Long after man discovered the value of minerals he used them but sparingly. N. S. Shaler estimated that as late as 1600 "there were only about twenty substances, other than precious stones, for which they looked to the underground realm. Clays for the potter and bricklayer, whetstones and millstones; iron, copper, tin, gold, silver, lead, sand for glass, mica, coal, peat, salt, and mercury make up all the important elements of this list."[5]

It was not until steam was put to work that there arose the need for metals and other minerals in quantity. As late as 1820 the people of the United States used, annually per capita, but five pounds of iron—the most common and necessary metal. A century later it required 597 pounds to satisfy their wants, and three years later 809 pounds. A like story could be told of other metals and minerals. Our use has shot up at an increasing rate until, as C. K. Leith has well said, "The world has used more of its mineral resources in the last twenty years than in all preceding time, and there is nothing to indicate a slackening of the acceleration which has occurred during this period. The production of oil, for example, is now as great for one year as for any ten years preceding 1900. . . . The last twenty-five years has seen as much gold production as the four hundred years following the discovery of America."[6] And again, "Here in the United States the per capita consumption of minerals has multiplied ten times in only forty years."[7] Such facts as to consumption lead naturally to questions of supply and distribution.

The Energy-Giving Minerals

George Otis Smith, Director of the U. S. Geological Survey, has pointed out that "the broadest classification of natural resources is that of energy resources and industry's raw materials," and the same classification can be made specifically of the mineral resources, fuels being the world's greatest sources of energy. Continuing,

[5] N. S. Shaler: Man and the Earth, New York, 1912, p. 5.

[6] C. K. Leith: The Political Control of Mineral Resources, *Foreign Affairs*, Vol. 3, 1925, pp. 541–555; reference on p. 541.

[7] International Control of Minerals, New York, 1925, p. 9.

Dr. Smith says: "Both in the quantity of power now used and in the energy stored up for future use the United States is preëminent. This abundance of mechanical energy, with which to lengthen and strengthen the arm of human labor, both increases the demand for industrial raw materials and increases our supply of metals, for instance, through reducing the mining and metallurgical costs. Herein lies the greatest stimulus to inventive genius, and the result is to make us not only greater consumers but greater producers. The net effect on our self-sufficiency in raw materials cannot be predicted. It is this sufficiency in power that makes America's future seem bright."[8]

It is the energy-giving minerals, coal and petroleum, that stand first in the service of mankind. Before modern times most of man's work was done by himself, his work animals, and his slaves. The Greek and Roman civilizations rested on slave labor. In Athens, at the time of her maximum glory, there were four slaves for each citizen, who furthermore drew a dividend from the state-owned silver mines at Larium instead of paying taxes. No wonder the voters could sit around in the shade of the temple groves and talk philosophy! In Rome the slaves won by war greatly outnumbered the citizens and left Romans free to fight. In later years, water power was developed and drove the slaves out of the bakeries, irrigation works, and the sawing of marble. Over the world as a whole but a few of the minor waterfalls were put to work until after steam came to be widely used and metals abundant. Even now less than 5 per cent of the power used in the United States comes from waterfalls, and if all the available power known were developed it would equal but one-fourteenth of our present total installed capacity. The wind never was used largely, save on the sea, and now yields us about one-tenth of one per cent of our power. The men and animals who for long centuries did the world's work had to be fed, sheltered, and persuaded or forced to work. This is no longer true. In steam and electricity man has found tireless, unsleeping, and powerful helps and ones which make no demand on his food supply. Only a part of the mechanical energy used by man is converted into electricity, but a memorandum from the Department of the Interior lately issued says: "The estimated output of nearly 80,000,000,000 kilowatt-hours of electric power for the United States in 1927, if it could be converted into equivalent man power, would provide the average family of about four persons in the United States with the services of eleven able-bodied mechanical laborers working eight hours daily, including Sundays and holidays, at a total cost for the eleven of about $75 a year." To these invisible slaves must be added those

[8] G. O. Smith: Theory and Practice of National Self-Sufficiency in Raw Materials, in "Raw Materials and Their Effect upon International Relations," *Internatl. Conciliation No. 226*, January, 1927, pp. 7–13; reference on pp. 10–11.

UNIV. OF

FIG. 2—Cartogram showing population and work output for certain countries. Compare Table I.

which come direct from steam engines. It is because of these power genii that the work output of the world and the consequent consumption and production of goods increase at a faster rate than food supply and wealth per capita pile up.

TABLE I—POPULATION AND WORK OUTPUT*

(Figures in thousands, 000 being omitted)

COUNTRY	POPULATION	WORK OUTPUT
United States	105,711	3,805,596
United Kingdom	44,169	1,060,056
Germany	59,853	897,795
China	427,679	513,214
British India	247,003	345,804
France	39,210	341,127
Russia	142,038	213,057
Canada	8,788	193,336
Czechoslovakia	13,611	156,526
Belgium	7,466	141,854
Japan	55,963	123,118
Italy	38,901	120,593
Poland	27,558	115,743
Australia	5,436	54,360
Holland	6,865	51,487

*Population figures for the year 1921; work output on the basis of population plus equivalent man power produced from water power and fuel, stated in terms of man days per year including human and mechanical work as recalculated from estimates by T. T. Read.

HUMAN LABOR VERSUS MECHANICAL ENERGY

Just how little of the world's work is now done by human hands is seldom appreciated. Thomas T. Read has brought together figures[9] to illustrate the difference between the work done in various countries and the number of people who live there. Any such figures are necessarily approximate, and the detailed results will vary somewhat with specific assumptions of equivalence chosen; but, remembering that two pounds of coal properly utilized will do the work of one man per day and that as actually used in steam-making three and a half barrels of oil consumed equal one ton of coal, and taking into account the developed water power in each country, figures that are at least of the right general order and proportion may be derived. Table I for the leading countries is based upon population figures for 1921 and Mr. Read's estimates of work output. From these figures it will be seen that countries are powerful not in proportion to population but in proportion to work. British India, for example, with 247,003,000 people exerts but a minor fraction of the force that

[9] T. T. Read: The World's Output of Work, *Mechanical Engineering*, Vol. 48, 1926, pp. 531–532.

France does with 39,210,000. China with four times the population of the United States has less than one-seventh the power. Russia, with two and one-third times as many people as Germany, does less than one-fourth as much work. It is work that makes wealth and power today. With nearly the same population France does almost three times the work of Italy because her resources are superior. A much clearer picture of the strength of the various peoples may be obtained if these facts be reduced to a map like Figure 2 than if areas and population be charted.

Just what this application of mechanical energy to supplement human labor means may be made clear by a few illustrations from the field of transportation.

The Cost of Primitive Transportation Methods

In unsettled parts of Africa transportation of goods is by carrier, the men marching along in single file with packages of goods on their heads. In parts where the white man's peace has not penetrated, and but a few years ago much of the continent was outside such limits, security of possession of property is so slight that a surplus of food sufficient for any considerable number of visitors to a village is not to be depended upon. It was formerly necessary, and still is in part, for caravans to convey their own food. But a man carries only 55 to 60 pounds and eats 2 pounds each day. Clearly he can go forward but 15 days, say two weeks, and have enough food to get back alive. Or two men may go forward one week and deposit enough food to enable a third to go two weeks farther. For every long journey into the interior it was formerly necessary to maintain an extensive carrier service unless, like Sherman, the explorer determined to live on the country, when he usually came to disaster. In 1902 when J. R. Farrell studied the copper deposits of the Katanga district in what is now the Belgian Congo, he was the apex of a pyramid of carriers numbering about 5000 and extending back through Bulawayo to the East Coast. Even so he had always to move quickly and sharply limit his stay in any one region because of possible food shortage. Contrast this situation with that in the same region now served by a railway. Great mills and a smelter turn out enough copper to threaten the balance of the world's trade in that metal. Elisabethville, the provincial capital, has all the comforts and luxuries of modern life; and as one drives out by motor car for tea and tennis in the afternoon or dines at its comfortable club in the evening, one realizes what minerals have both led men to do and also permitted him to accomplish in the far-off parts of the world.

Again contrast Major G. St. J. Orde Browne's recent report[10] on

[10] *British Colonial Repts. No. 19*, London, 1926, p. 37.

"Labour in the Tanganyika Territory" in which is discussed the "almost incredible" wastage entailed by the porter system of transport.

As an illustration of the amount of labour absorbed in this form of employment may be cited the figures for the station of Kilosa; during the year 1924, porterage for Government loads alone accounted for 400,000 working days, i. e. the entire labour force of a considerable plantation. In addition to this, there were probably even larger numbers engaged by private employers, since the economic development of the country still largely depends upon head porterage. The above is a good example since it has been possible this year to introduce motor transport from Kilosa to Iringa, with the result that the former figure has already been largely reduced.

In China man's first great mechanical invention, the wheelbarrow, is still used largely for transportation, mainly for freight but occasionally for passengers as when the women workers in the textile mills at Shanghai ride to work in parties of eight back to back as in an Irish jaunting car. A wheelbarrow, if handled by one man, will carry ordinarily 250 pounds, but the load may be increased for short distances to 400 pounds. The cost of transport is high despite the low standard of living of the barrowman. It works out to 15 or 20 cents gold per ton mile, and the limitations of such transport are close. In famine times food has been carried 70 miles, but the effective limit worked out to much less. Unless some food is available en route, that used by the barrowman in going and coming cuts deeply into the load. A modern locomotive carrying 18 tons of coal and 15,000 gallons of water for its own use can haul a train a mile and a half at 40 miles an hour over one-per-cent grades. It does the work of 65,630 wheelbarrow collies and does it more rapidly and surely. A coolie delivering coal balls by the basket in Peking, say, carries about 65 pounds and goes about two miles in one hour, earning about 50 cents a day. A negro in Washington delivers coal by the truck load of seven and a half tons. He goes 12 to 14 miles per hour, works 8 hours, and receives more per hour than the Chinese does in a long day. He does the work of nearly 1400 coolies.

It is the same thing with water transportation. A type of canoe used on the rivers of Colombia carries 4000 pounds. Poled upstream it may make 8 miles per day, depending on current and depth of water: or it may make 40 miles downstream perhaps. A steamer of the Great Lakes carries 13,000 tons of coal and travels 10 miles per hour and is essentially independent of current. It would require 6500 canoes merely to carry the same tonnage regardless of rate of speed and delivery.

Minerals as an Incentive to Pioneering

The earliest form of ocean transport was by small wooden coast-following boats propelled by oars or leather sails. Their radius of

action was short and their carrying capacity small. Even the Greek and Roman triremes with ten marines, twenty sailors, and one hundred and seventy rowers had but a short radius of action. By contrast the airplane carrier *Saratoga*, with more officers than the trireme had rowers, can go anywhere and has a power plant equivalent to that of 2,000,000 galley slaves. The trade of ancient days was conducted by small boats that kept close to shore on account of the need of food and water as well as because of difficulties in navigation. Transport was expensive. Hence, the most compact goods or those that were most valuable by reason of their scarcity were favored in this early trade. The Frieslanders brought to England furs and amber from the Baltic and took away gold from the Irish mines and tin from Cornwall. It was tin apparently that drew the Phoenicians, and later the Romans, to Britain, and gold that lured the *conquistadores* across the weary miles of North and South America; and indeed mines have ever been a most powerful incentive to exploration and trade.

The diamonds of Kimberley and the gold of the Witwatersrand brought the railroads and cities of the white man at one leap into the heart of the black continent and thereby precipitated conflicts of race, of ideas, and of economics all at once. Before metals were used in quantity and railways were built, such a sudden jump of the frontier would have been impossible. Penetration was necessarily slow and by stages. Men's minds as well as roads had to be prepared; and the slowly built bridges of acquaintance were extended across the gulf between peoples instead of quickly thrown bridges of steel across the rivers. The whole method of frontier conquest has been changed by the new servants won by man, and the problems of human contacts that have resulted are as severe as problems of food supply and of raw materials. The rate at which copper can be produced in Katanga is largely determined by the rate at which the necessary labor can be collected and converted from primitive habits of life and simple communism into individual workers motivated by a desire for things previously outside their range of hope of attainment or even knowledge.

Development of minerals not only complicates the problems of conquering the frontier by introducing a new element of speed, but the importance of the larger mineral deposits to modern industry and to national security introduces new motives of action. Disregard of the influences that flow from our mineral environment can only lead to international friction and from time to time to national disaster. It becomes vastly important to determine what are the special characteristics of mineral deposits that made them factors in the settlement of a country and in its political and commercial policies.

Problems in the Utilization of Mineral Wealth

Unfortunately, but little systematic study of these problems has been made. Before the World War the significance of minerals was little appreciated save by those engaged in their production. The producers had been so successful that manufacturers and users had come to expect a sufficient supply with no more personal responsibility for keeping it up than for maintaining the sunshine. It is true that in President Roosevelt's administration conservation began to be discussed; but attention was fixed more on timber supply and soils than on minerals, although even then it was coming to be seen that ore deposits are exhaustible and oil and coal deposits have a limit. So little, however, was the significance of these facts realized that taxation for years afterward was levied on minerals as on any other property and no account was taken of the fact that output inevitably represents depletion of capital.

It was only when the world realized that the war would be won not by number of men but by volume of materials, when sudden demand was created for quantities far beyond current production, and when serious scarcities appeared, that governments and peoples alike had it borne in on them beyond escape that minerals are not like other natural products, that they cannot be transplanted and raised at will, that no second crop will follow the first, and that while the energy-giving minerals are totally consumed in use, the metals and other minerals have a permanent value and in part may be used over and over. Just how large a factor re-use may become was not realized even by metal users until the scrap from battle fields and munition works after the war disorganized trade and shut down great plants designed for producing virgin metal. As late as three years after the war one large copper smelter in the United States was restricting ore purchases in order to re-melt a supply of new copper tubing bought as junk. Such maladjustments exact a heavy price from industry. The relation of man to minerals would seem to be as important as to climate.

Probably the most comprehensive studies of these problems that have been made were those undertaken by the Committee of the Mining and Metallurgical Society of America on Domestic and Foreign Mineral Policy, and of the American Institute of Mining and Metallurgical Engineers on Industrial Preparedness. It was only last August that Sir Thomas Holland, at the opening session of the British Empire Mining and Metallurgical Congress in Montreal made the plea that led that body to decide to take up similar studies. Earlier there were the reports of the International Geological Congress on iron ores[11]

[11] The Iron Ore Resources of the World: An Inquiry Made upon the Initiative of the Executive Committee of the XI International Geological Congress, Stockholm, 1910, 2 vols., Stockholm, 1910.

and on coal,[12] though these were inventories of reserves rather than broad studies of the relations of man and his activities to minerals. A number of individual books also have been printed that bear on or fringe the subject, such as those of J. E. Spurr[13] and George Otis Smith,[14] and a considerable number of interesting individual magazine articles have appeared, several in *Foreign Affairs*, for instance. It has engaged the attention of the Council on Foreign Relations.[15] The whole matter was the subject of one study group at the Institute of Politics, Williamstown, Mass., in 1925 and 1926, and there have been numerous evidences of an awakening interest.

The studies of the American Institute of Mining and Metallurgical Engineers and of the Mining and Metallurgical Society of America already mentioned, which studies, as it happens, have been reprinted in a single booklet,[16] come most nearly to giving a comprehensive review of the subject. Even so they were directed mainly at the problem of supply as an element in national defense and leave much unsaid about minerals from other points of view. Drawing, however, largely upon this report, the following general summary may be made of the more significant facts as to minerals.

Minerals a Limited Resource

Unlike the products of the animal and plant kingdoms, minerals are not reproducible. Whatever of them we are to have is already here in the earth under our feet. There is no known way of increasing the quantity or renewing a supply once exhausted. One crop, and one crop only, exists. Water running down from the mountains to the sea and turning perhaps a dozen power wheels en route may be evaporated by the sun's heat, travel as clouds to the mountains, fall as rain, and go down a second time or any number of times to the sea. Coal, however, burned under a boiler gives up all its energy in one burning. The gas and ashes into which it changes have no more energy to yield. A pine forest, logged off, may be succeeded quickly by maples or other hardwood trees under whose protecting shade a second pine forest may get a start; but an iron mine once worked out has no more ore to give. The fields of southwestern Missouri and adjacent parts of Kansas and Oklahoma have yielded crop after crop of grain or fruit for many years and may continue to do so indefinitely; but one may wander among the piles of waste

[12] The Coal Resources of the World: An Inquiry Made upon the Initiative of the Executive Committee of the XII International Geological Congress, Canada, 1913, 3 vols., Toronto, 1913.

[13] J. E. Spurr, edit.: Political and Commercial Geology and the World's Mineral Resources: A Series of Studies by Specialists, New York, 1920.

[14] G. O. Smith, edit.: The Strategy of Minerals, New York, 1919.

[15] The first of the Council's Research Publications (1927) is "Ores and Industry in the Far East," by H. Foster Bain, briefly reviewed in the *Geogr. Rev.*, Vol. 17, 1927, p. 517.

[16] International Control of Minerals, New York, 1925.

and tailings, note the abandoned shafts, plot the shift of mining activity to the Southwest as the years have passed, and find abundant proof that the zinc and lead beneath the fields can be mined but once. The total amount of mineral available to man is fixed. It is a definite reserve against which he issues drafts.

A certain modification of this statement must, however, be noticed. While the total present is fixed, the amount available for use from time to time varies. It happens that most useful minerals occur in many degrees of mixture with those of little or no use. Production requires the separation of the useful from the non-useful; and fortunately technology, methods of organization and management, the tools of industry, and the capital available for use all improve or increase as the years go by so that it becomes possible progressively to work bodies of ore that contain smaller and smaller proportions of the useful minerals or metals. Today a third of our great copper production is won from rock that contains so little of the metal that twenty years ago it was not considered worth taking into account. For the same or similar reasons man is able as necessity arises to go deeper and deeper into the earth and mines 6000 feet deep are now profitably operated on the Rand even though gold exchanges for less in other goods than when gold mines were but a few hundred feet deep. Oil wells more than a mile deep are now not uncommon, though it was only in 1859 that the Drake well with a depth of only 67 feet started the modern petroleum industry. These and similar victories over nature have been won because of the power of men's minds, and in that power lies the best assurance that even the constantly growing demand for minerals will somehow be met.

One may properly have great faith in man's power to solve his difficulties as they arise, and yet one may hold that it is advisable to avoid such difficulties if possible and to take full account of them in any event. An exhaustible resource is clearly one for special treatment. If this country were told that after a fixed period no more wheat could be grown within its limits, definite steps would be taken to make ready for that contingency. When it was shown that if unchecked the boll weevil would within a limited number of years destroy cotton farming, there was no limit to the men and money made available to find a way to prevent such a disaster. But hydraulic gold mining has stopped; gold dredging has nearly ceased; and gold mining itself is a dying industry. Whole areas have been deserted because of the decay of silver mining; the natural gas belt of Indiana is but a lurid memory of waste. Yet when one suggests the possibility of the exhaustion of our oil fields or the advisability of permitting such organization of the coal industry as will prevent four tons being wasted to mine six, he is apt to be called an alarmist and certain to be considered a nuisance. A people who hold within

the limits of their country great mineral resources are trustees of an asset that belongs to the world and in which posterity as well as the present may rightly claim a share; and they are charged with responsibility for thoughtful consideration in its development and use.

The Irregular Distribution of Mineral Deposits

Mineral deposits are irregularly distributed over the world. Nature has scattered her favors unequally. The Lake Superior region is characterized by great deposits of copper and iron, but it would be useless to look there for coal. Coal occurs in abundance in Illinois and in Western Pennsylvania; but in neither does copper occur, nor is iron present in significant amounts. Gold is not found in Iowa nor, so far as known, petroleum in Nevada. Antimony is not mined in Florida, nor phosphate rock in more than most meager amounts in China. If one of China's antimony mines could be moved to Florida in exchange for a few square miles of phosphate rock, each country would gain greatly thereby. The Federated Malay States contain only one mine of low-grade coal, but they dominate the world in tin production. The United States contains hundreds of coal mines and the world's largest coal reserve, but no amount of oratory or tariff assistance will put tin in the rocks of our mountains where nature has not formed it. If all of us are to enjoy the bounties of nature even in a minor degree it is clear there must be an exchange of minerals and metals. International trade in minerals and metals is a trade that cannot be blotted out. It is possible to transplant rubber from Brazil to Malaya, but it is not possible to move Brazil's manganese to the United States save ton by ton. We make in this country some 40,000,000 tons of steel per year. For each ton we need about fourteen pounds of manganese, and unless we learn ways of using much lower grades of ore than are now employed in manufacture we must continue to import high-grade ore or ferro-alloys. In this instance we have some choice of whom to deal with, since Russia, India, West Africa, and Brazil all contain large deposits of favorable grade. In the case of other metals it frequently happens that less choice is open. Canada dominates the nickel supply of the world. Canada and Belgium divide the world's market for cobalt equally between them. Malaya, Netherlands East Indies, and Bolivia furnish most of the tin, with Siam, China, and Nigeria supplying minor amounts. The United States and Italy provide the world with its sulphur and meet only the competition of pyrite burners, the Rio Tinto region of Spain furnishing the major supply. Italy, since the war, dominates the mercury market, although Spain has the richest mine. So high have prices been set for this minor but essential metal that mines in the western United States find it profit-

able to work ores containing as little as four pounds of mercury in a ton of rock. Everywhere the distribution of minerals is unequal, and the demand is even less well adjusted since the centers of industry are fixed by a combination of factors among which the presence of coal and iron are dominant. In general terms the other minerals flow to the areas where these are to be had, and surplus goods go back in payment.

Use and Value

Differences in properties, uses, availability, and consequently value enter into fixing the lines of trade in minerals. Some minerals have a limited field of usefulness but are none the less almost indispensable. Platinum and mercury may be cited. No large use is known for either, but where they are needed the need is so great that a high price per ounce and per pound respectively does not prevent their employment. Tin is in a slightly different category. If it were cheaper it would be more widely used. Even as things are, substitution is practiced wherever feasible to the benefit of lead, cadmium, and aluminum. Where tin is essential or so much better than anything else as to be virtually so, as in food containers, the amount used is so small a portion of the package sold that a rise in price from 30 to 70 cents a pound makes no difference to the ultimate purchaser of say a can of tomatoes and so is no bar to its continued use. These are minerals which are produced and sold by the ounce or the pound. They illustrate a class of which it is true that production at a distance is no bar to general use because the amount of transportation required is small. It is the same phenomenon as the sale on the Pacific Coast of a garment made in New York at a less price than in the city of origin, the freight on the light weight amounting to less than the difference in rental of selling space. With bulky minerals the situation is different.

Iron ore is rarely shipped long distances save where cheap water transport is available, and all over the world iron ore moves to the coal fields to be made into steel rather than the reverse because coal is bulkier and because coal fields beget industry and industry consumes steel. Save to a limited extent as back-flow freight, it does not pay to ship coal to iron-ore regions to make steel. One would need to reload the steel and ship it back to or near the coal fields in order to find dense consumption. It is the peculiar characteristic of coal that it gathers around or near it factories and industries by furnishing workers that do not eat, which makes it incomparably our most important mineral, truly the "mainspring of civilization" as Newberry once characterized it. Whether the much discussed project of burning the coal at the mines, generating electricity, and transmitting the latter to industrial centers will ever be effected

on a large scale is doubtful. For one thing power-making requires quantities of water as well as coal, and for another the great cities are most of them not far from coal fields or at least within such distance that the available transportation does not more than double the mining cost of coal. For the ordinary American householder the price of his coal consists of three nearly equal parts, mining cost, transportation, profits and trading costs. The large industrial buyers manage to squeeze out most of the third item.

The correlation of coal fields and industry is not exact. Many exceptions can be found, and much coal is shipped long distances. Indeed, for many years England balanced her foreign trade by shipping coal around the world; but countries without coal are heavily handicapped in industrial competition and, as to war, are necessarily under bonds to keep the peace. A country having coal has something for sale for which there is a wide market; and even though it may not sell coal it has still the power with which to manufacture goods and so, even when raw materials must be largely bought abroad, may retain the profit due to manufacture. It has a special advantage in the so-called heavy industries, such as steel making, metal production, and tool manufacture. What all this means may be seen in the contrast between France and Italy. It has already been pointed out that these countries have about the same population but that in France nearly three times as much work is done. France is now independent as to coal supplies, while Italy must import almost all that it uses. Ingenuity, skill, and hard work, no matter how faithfully they be applied, cannot altogether overcome the handicap of poverty of mineral resources. The intense industrial activity, the rapid rise in wealth, and the dominant position in world affairs held by North America and Western Europe are due to many causes; but among the most important have been the presence of and the will to use their abundant mineral resources, of which coal stands first. Petroleum has, in recent years, climbed rapidly to an importance long denied to it; but in the form of the crude oil from wells it is of only temporary importance, all the more as the demand climbs to millions of barrels a day. No serious student doubts that in a short period—short as world affairs go—the oil wells will drop to a secondary place and our main reliance for petroleum will again be coal as in early days; with shale oil to supplement it. Many of the industries that now depend upon crude oil burned under boilers for power will, without doubt, eventually return to burning coal. With the keenest appreciation of petroleum as an incomparable gift of nature we can hardly look to oil fields themselves as likely to determine permanent loci of industry.

It is obviously to the general economic good that minerals and metals, which seldom occur pure in nature, should be dressed and

refined at the nearest feasible assembly point. It is better to ship copper from Chile than copper ore, if the amount available will feed a smelting plant of sufficient size to constitute an economic unit. This is true despite the necessity of importing oil for fuel. On the other hand, copper-bearing pyrite produced in northern Norway has been shipped to southern Sweden as ore because the copper, iron, and sulphur can all three be used to advantage there. In other situations where pure sulphur can be laid down cheaply its advantages in the smaller furnace capacity needed, in less deterioration when stocked, and in other particulars have operated to stop a previous flow to the region of iron pyrite. Pure materials can be shipped a long distance, but impure ones are best refined as near the source as may be, thus conserving transportation and giving to the country of origin the benefit of minimum manufacture at least.

Exploitation: Importance of the Large Mineral Deposit

It follows from what has been said that if the world is to continue to enjoy the civilization of the present and if the benefits of the latter are to be felt lower and lower in the social scale and to spread farther and farther into the backward countries, immense quantities of minerals must be dug out of the earth and set to work. A large portion of this material will necessarily be transported in the form of raw or semi-finished products from one place of origin to another, and goods made from these minerals or by their use will need to be shipped back or exchanged for still other goods. A great network of industry is inevitable, and it is equally certain that it must be international. No country is wholly independent as to mineral products. Our own is as rich as any; but our industries cannot now be sustained by the output of our mines only, great as that is, for the reason that in the case of numerous minor but essential minerals the deposits do not exist in the United States. Every country finds itself more or less in the same condition and so has an interest in maintaining the utmost permissible freedom as to exploration, development, and trade in minerals. A tariff to encourage sugar raising at home or to equalize costs of manufacturing between countries is understandable, but a tariff to promote mining a mineral that does not exist or is present only in insignificant amounts is absurd. A reasonable export tax, in countries where such taxes are legal, on any product shipped out of a country may be defensible as a matter of revenue production; but a restrictive tax to capitalize natural monopoly inevitably provokes retaliation. The best interests of the world are not so served.

No complete inventory of the world's mineral resources has been made. It is believed that the large outlines are known. Not all the coal, iron, copper, lead, or zinc deposits have been surveyed, but

under modern conditions a large deposit can be developed and operated with so much greater economy than the same tonnage in a number of small ones that the large deposits as a class have a virtual monopoly. It is the same as in work. Merely to carry the load pulled by one modern locomotive would require 40,000 men and to transport the same number of tons in the same time would call for 2,220,000. Even small railroads buy locomotives fifty at a time, and it is clear that it would be out of the question to do by hand labor what the locomotive does. It is equally true that if we had to draw our 75,000,000 tons of iron ore each year from little deposits yielding even 100 tons a day, the service of supply would break down. In studying the possible development of a certain coal field in China from which at the time a trickle of coal came out by native boats, it became clear that there would not be surface enough on the river to accommodate enough native boats to transport the output of a modern colliery. The very size of modern industrial units makes some things possible and others impossible, and this is as true in the development of minerals as in other modern work. There are many reasons for believing that the large mineral belts of the world are already outlined.

Foreign Exploitation and National Sovereignty

A fear or jealousy crops up from time to time over development of mines by foreign capital—a feeling that in some way national sovereignty or proper political loyalty is impaired. Under any reasonable contract or system of regulations this is unwarranted. It is entirely possible, indeed it is now usual, so to conduct operations that benefits result both to the foreigner and the native citizen from converting a future into a present value. It is a fear hard to kill, however, and occasionally it is expressed even among such good friends as English, Canadians, and Americans. The sound point of view has been excellently set forth by Sir Robert Horne, speaking at the banquet of the Empire Council of Mining and Metallurgical Institutions in London November last:

> For my part I am glad to see American capital developing Canadian resources. It is much better that those resources should be developed than that they should remain in abeyance. I, of course, regret that more British capital is not available for the purpose, for the reason that the profits to be obtained from the use of the capital would come to Britain, and also because the supply of that capital would bring employment to this country, for all the money that goes out to another country from here goes ultimately in the form of goods. Therefore, I would rather see British capital invested in Canada than American, but I would rather see American capital invested than no capital at all. ["Hear, hear."] The real truth is that countries are not controlled by the capital which they bring in from the outside. We have got the most sinister example to the contrary in Russia, which employed vast amounts of capital from other countries, but had absolutely no concern for those who provided it when it came to political action. Government depends upon the

character and desires of the citizens, and I am confident that, whatever American capital may go into Canada, there will be no weakening of Canadian loyalty to the British throne.

Capital necessarily serves the country in which it labors and in no way does it serve better than in bringing in modern knowledge, machinery, and management to open up and set to work the minerals with which nature has endowed a land. To allow these to lie dormant in the earth is but to turn one's back on the modern world and return to the primitive living of our remote ancestors.

EXPLORATIONS IN THE COAST RANGE OF BRITISH COLUMBIA

W. A. Don Munday

THIS is the narrative of two expeditions in which Mystery Mountain (Mt. George Dawson)[1] was located and its altitude determined as over 13,200 feet, thus making it the culminating peak of British Columbia if Mt. Fairweather, 15,827 feet, which lies partly within the northern extremity of the province be excluded. Mystery Mountain is in the Coast Range 24 miles from tidewater. Even so late as 1925 the Chief Geographer of the province, describing its physiographic features, could say of the Coast Range that "apart from the lofty section at the northern limits of British Columbia . . . there are no known peaks as high as some of those of the Rocky Mountains."[2] In that year came the first confirmation of vague but persistent rumors of more lofty mountains. Dr. V. Dolmage, of the Geological Survey of Canada, reported peaks over 10,000 feet; and "one exceptional peak, judging by instrumental observations made on it from several triangulation stations, is over 13,000 feet."[3]

While the Canadian Rockies have claimed much attention, especially in the last 20 years, the Coast Range has been comparatively neglected. Many thousands of square miles remain unexplored, even within comparatively short distances of well established routes of travel of the past or present day. Yet this part of the country has much to offer both geographer and mountaineer. The great inlets of the sea "rival in their magnificence all examples of the fiord type in the world."[4] Inland is a striking scenery of narrow trenchlike valleys and jagged peaks piercing widespread glacial areas. Nowhere else on the North American continent south of Alaska are glacial features so extensively developed as between the Bella Coola and Toba

[1] Since this was written the Geographic Board of Canada has given the name Mt. George Dawson, in memory of the eminent Canadian geologist and geographer whose name is also borne by the chief town in Yukon Territory and by the Dawson Range and Mt. Dawson in the Selkirk Range. Provincial authorities unsuccessfully urged the name "Mt. Waddington" in honor of a pioneer prominently associated with the adjoining territory. J. E. Umbach, Surveyor-General of British Columbia, informs the writer that he regards the mountain as the highest in British Columbia.

Most of the names used here have not been passed upon by the Geographic Board of Canada, but the majority have received the tentative approval of the British Columbia representative.

[2] G. G. Aitken: The Progress of Survey and Settlement in British Columbia, *Geogr. Rev.*, Vol. 15, 1925, pp. 399–410.

[3] V. Dolmage: Chilko Lake and Vicinity, British Columbia, *Canada Geol. Survey Summary Repl.*, 1924, Part A, pp. 59–75, Ottawa, 1925. The official triangulation by the Department of Lands of British Columbia is 13,260 feet.

[4] J. A. Bancroft: Geology of the Coast and Islands between the Strait of Georgia and Queen Charlotte Sound, B. C., *Canada Geol. Survey Memoir 23*, Ottawa, 1913, p. 20.

Rivers, in the midst of which region stands Mystery Mountain. A zone of glaciation of 5000 feet on 8000-foot peaks is commonplace, and nearly double this exists in several instances among the higher mountains. Mystery Glacier descends to within 500 feet of sea level six miles from tidewater. It is not improbable that at least one snowfield in this region will prove to be even larger than that of the Columbia Icefield, 110 square miles.[5]

First View of the Mountain, 1925

The writer's interest in the Mystery Mountain region took definite shape as the result of a trip to Mt. Arrowsmith in June, 1925. Although only 5976 feet high, Mt. Arrowsmith is the dominant massif of the southern half of Vancouver Island and offers a view which, in extensiveness and interest, is out of all proportion to its height.

In the wake of a severe snowstorm above the 3000-foot level, the atmosphere possessed the clarity usual before the summer's destructive forest fires begin. For 150 miles the Coast Range reared 8000 feet and more above the moat of the Strait of Georgia, its snowy battlements still decked with many cloudy banners of the passing storm. Almost due north we discovered amid the clouds the black bulk of a massive mountain, too rugged to be whitened by the storm and apparently the monarch of its district. It was readily picked out with the naked eye. In the light of the information then available this seemed likely to be Dr. Dolmage's big mountain.

In search of this unmapped mountain we sailed the following September on the coastal steamer *Chelohsin* to Orford Bay, a logging camp 15 miles up Bute Inlet and 160 miles from Vancouver. Here we met Jack McPhee, a trapper living the year round at the head of Bute Inlet which is 40 miles long. He told us of the semblance of a hunting trail extending through the timber of the lower slopes of Mt. Rodney, 7843 feet in height and distant about two miles from tidewater near the head of the inlet, and agreed to take us along in his boat. A combination of circumstances made the climb to timber line particularly trying. Weather proved inclement, but altogether three peaks were ascended, the main peak of Mt. Rodney leaving nothing to be desired as a viewpoint. In the four or five thousand square miles visible rose innumerable peaks, not a score of which are even named, while only the main rivers are mapped.

Merely from the standpoint of mountaineering difficulties, the group of eight and nine-thousand-foot mountains close to Mt. Rodney on the east side of Bute Inlet suffer little in comparison with any ordinary group of summits in the same latitude in the Rocky Moun-

[5] Report of the Commission Appointed to Delimit the Boundary between the Provinces of Alberta and British Columbia, Part II, Ottawa, 1924, p. 62.

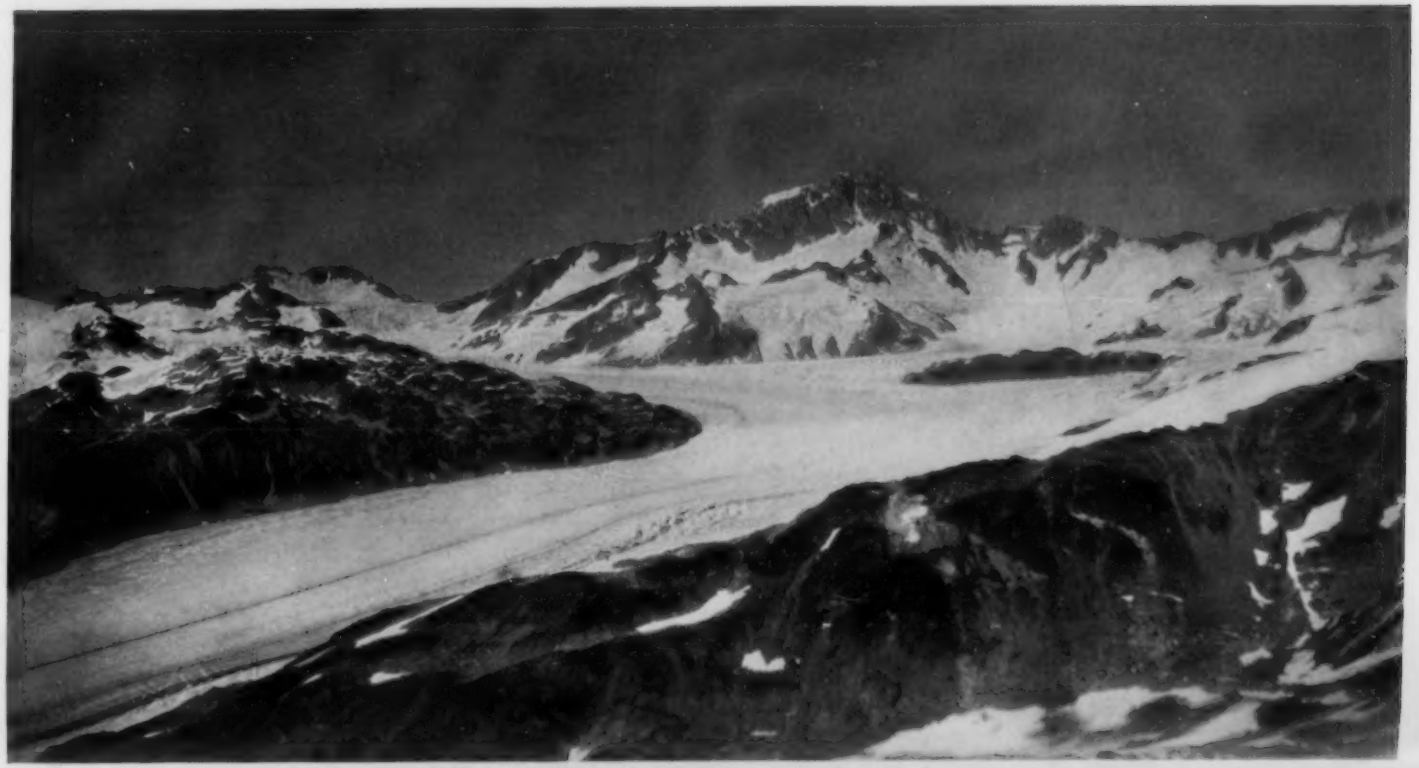
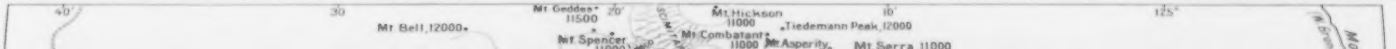


FIG. 1—Mystery Mountain (Mt. George Dawson), believed to be the highest peak of British Columbia. Mystery Mountain in center, Mt. Munday extreme right, Spearmen Peak between, Mystery Glacier in front.



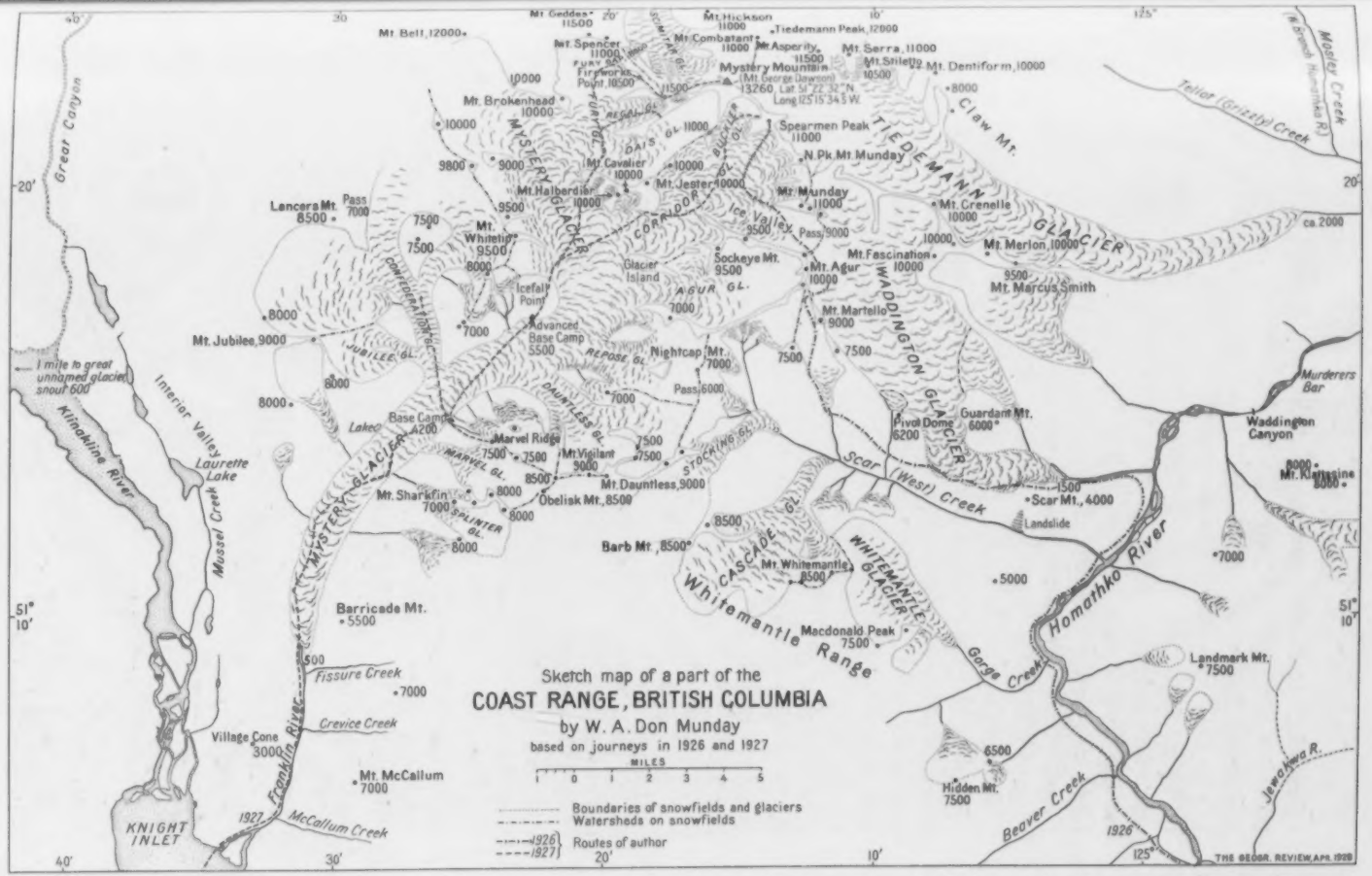


FIG. 2—Sketch map showing the routes of the 1926 and 1927 expeditions to Mystery Mountain (Mt. George Dawson). Scale approximately 1:300,000. Compare Figure 3.

tains. Mt. Massive, the mountain that had lured us forth, was still 30 miles away to the north. Its form strongly suggests that it is volcanic in character. But in spite of being fully 10,000 feet in height, it was now seen to be completely outranked in altitude by a lofty range to the west. These greater peaks rose in orderly succession westward, culminating in a giant of unchallenged supremacy. Wave-like ridges of seracs on the icefall of the S-shaped southern glacier of this group showed clearly, although 35 miles away up the Homathko River, the larger of the two rivers flowing into the head of Bute Inlet.

On our return from this preliminary trip we stood in some risk of missing the *Chelohsin* on her weekly call at Orford Bay because our friend McPhee had been severely assaulted and his boat and engine damaged by Indians. Fortunately for us, he was able to make his way to the only other white resident north of Orford Bay who came to our rescue—we were marooned on the precipitous shore of the inlet without fresh water. Indians passing in their fishing boats had declined to help us in any way, being hostile to all whites owing to determined efforts to compel them to obey essential fisheries regulations.

The Homathko Valley

As the estimated distance of the big mountain from tidewater did not exceed 45 or 50 miles, its exploration did not appear unduly formidable at first sight. But from long experience with trail-less valleys of the Coast Range we have learned that here distances are best measured in terms of hours and days. The Homathko valley, up which our route was to lie, has its source in the interior plateau near the headwaters of the Chilcotin tributary of the Fraser. It nearly became a main artery of travel to Central British Columbia. In 1863–1864 Alfred Waddington had under construction a toll road to the Cariboo gold fields. This project halted abruptly when Chilcotin Indians massacred his trail gangs without warning. The Chilcotin War followed, ending with the hanging of five of the murderers. But the disaster had practically bankrupted Waddington, and trail work was never resumed. The motives of the Indians were plunder and revenge. The Chilcotin tribe had been nearly wiped out by smallpox, said to have been spread by unprincipled white traders in 1862 by the plundering of Indian graves of infected blankets for sale to the Indians; these traders, it was said, threatened to bring back the scourge upon the remnant of the tribe.

Waddington's name is perpetuated by Waddington Canyon 30 miles from the mouth of the Homathko River, Waddington Channel near the mouth of Bute Inlet, and Waddington Harbor at the head of the inlet although it has little to commend it as a harbor. In 1874–1875

the Canadian Pacific Railway ran a reconnaissance line along the Homathko River; but naval advisers of the British and Canadian governments recommended choice of Burrard Inlet in preference to Bute Inlet as the Pacific terminus of Canada's first transcontinental railroad. Difficulties of travel in the Homathko valley brought one of these survey parties measurably near starvation.

Waddington optimistically described the river as "entirely navigable for river steamers for 36 miles," and a similar statement rashly incorporated in the British Columbia Pilot survived there for 50 years. For many years navigation was completely blocked by a log jam four miles from the mouth. Apart from this the river is full of obstructions, as we amply proved during our trips to bring in supplies for the season's work. In less than 30 miles it falls 525 feet. One trapper works along the river below the canyon for a few months in winter, but there is not a single settler in the valley. Several thousand acres of good agricultural land are barred from settlement by a government reserve across the mouth of the valley.

FIG. 3—Map showing the location of the Mystery Mountain (Mt. George Dawson) region. Scale 1 : 7,000,000.

EXPEDITION OF 1926: UP THE HOMATHKO

Early in May, 1926, preparations for the expedition to the mysterious mountain were begun. Supplies were taken in and cached at a point eight miles up the Homathko, where we had found a trapper's cabin hidden on an island. Our party[6] was finally assembled on May 31 and in chilling rain we left McPhee's. Beyond the trapper's cabin transport became increasingly difficult with every mile. The river rarely united in a single channel or was unobstructed for any distance; jams and driftwood consisted of anything up to whole trees six feet in diameter. Frequent long portages caused serious delays and often necessitated the cutting of a trail.

[6] Consisting of T. H. Ingram and my wife and myself, members of both the Alpine Club of Canada and the British Columbia Mountaineering Club; E. A. Agur and A. R. Munday, members of the Alpine Club; and R. C. Johnson.

We had to follow the river 25 miles measured in a straight line. In summer months the river is from 300 to 1500 feet wide and turns its flood plain into a network of channels as it sweeps back and forth against the foot of the cliffs; the valley averages about two miles in width. Bushes flourish with amazing luxuriance on the fertile flats, being further interlocked by crushing winter snows. Silt from the river invades and kills mature forest, and a mass of windfalls adds still further obstacles across the adventurer's path. Except for the absence of the sea, the mountain walls continue the fiord type of valley inland for 30 miles without any change. It is little wonder that former travelers through the valley in days when a trail existed learned nothing of what lay above and beyond the towering mountains enclosing the mighty gorge. Elevations of 7000 feet are attained in most places less than two miles from the valley floor, with higher summits in sight behind.

Heakamie Glacier came into view when we were 12 miles up the valley. From an unrevealed source it winds down a canyon five miles to an elevation of less than 600 feet in the main valley. Jewakwa Glacier, four miles to the north, issues from the same snowfield, which in all probability will be found greatly to exceed 150 square miles in extent. We saw much of it from higher elevations later; beyond this, it is entirely unexplored. It appears to average less than 8000 feet in elevation but encircles a number of prominent peaks far higher. Other glaciers issue in various directions from it.

A sudden rise of the river of 40 inches in 24 hours split our party for two days before all supplies and equipment were reassembled, and we finally decided to cache the canoe. Thereafter we back-packed everything, relaying forward about half a mile at a time, a good deal of trail cutting being needed.

Short passable sections of the old Waddington trail on the east side of the river would have helped undoubtedly; but, as it turned out, we could not have got back to the west side of the river owing to its great swiftness nearer the canyon. "Gorge" and "Scar" creeks proved formidable barriers, being too turbulent for fording and too wide for felling trees across successfully, so that we had to contrive bridges.

Animal life abounds in the valley: traces of bank beaver were numerous, wolf tracks common, deer tracks frequent, though only one doe was seen. All kinds of bears inhabit the region, but we heard them more often than we saw them. Geese with young were noted seeking shelter in brush in preference to water.

Waddington Glacier

Ten days behind schedule, we arrived at Coola Creek, supposed course of "the Bella Coola trail" according to Waddington's old map.

FIG. 4

FIG. 5

FIG. 4—The 7000-foot glacier-hung wall of Homathko valley near river mouth. (Photograph by Mrs. Don Munday.)

FIG. 5—Approaching Waddington Glacier, Mt. Guardant beyond. Southern moraine, 400 feet above the ice, marks tremendous shrinkage of glacier which is going on. Elevation 1400 feet. (Photograph by Mrs. Don Munday.)

This is a mistake, as the valley offers access only to high glacial peaks and passes, the creek draining the big S-shaped glacier which we had seen from Mt. Rodney and the lower river.

Exploring this creek, Mrs. Munday and I found the tongue of Waddington Glacier two and a half miles from the river and at an

FIG. 6—Glimpse of Heakamie Glacier from Homathko River at 200 feet above sea level. (Photograph by A. R. Munday.)

elevation of only 1500 feet. The river is about 450 feet above sea level at the mouth of the creek. Four well defined moraines mark a retreat of only 400 yards from the mature forest of hemlock, fir, and cedar; on the outer moraine trees of the same species were judged to be less than 100 years of age. This retreat does not suggest the actual shrinkage of the ice, however. The glacier now occupies only one half the valley for a mile, the present south lateral moraine splitting the valley in two with its 400-foot ridge. The abandoned bed is densely grown with young conifers to the very crest of this moraine, which caps a ridge of rock in part at least. We followed the crumbling crest of the moraine a mile to a broad embayment of semi-stagnant ice at the head of the green valley and crossed the ice to the next rock promontory.

The south side of the glacier is marked by three deep bays eroded in micaceous schist of unequal resistance. The rock has a more or less vertical cleavage, and rapid erosion has undoubtedly enabled the Coola valley to capture the entire flow of Waddington Glacier within comparatively recent geological times. The former course of the glacier from its snow reservoir was directly south into Scar valley, and in the broad gap west of Scar mountain the present southern moraine forms almost, or actually, the crest of the watershed between the two valleys. That this diversion of Waddington Glacier profoundly affected Scar valley, which formerly must have been dammed with this ice flood, is suggested by the presence of moraines to the westward at least 2500 feet above the floor of the valley.

Camp was shifted in two relays to Cliff Camp, at 3500 feet, beside the glacier. Rain also interfered with the next advance which was partly on the moraine, partly along cliffs, and partly along the glacier to the "Big Bend." Thence we climbed through open timber on snowy slopes on the north side of Scar Creek. For a long distance the

FIG. 7—The Big Bend of the Homathko River, Gorge Creek entering from right-hand valley. (Photograph by A. R. Munday.)

mountainous icefall uplifts mightily above the margins of Waddington Glacier. Doubtless it pushes along a central ridge. A mile from the glacier a bit of nearly flat ground bare of snow invited pitching our three small tents at 4800 feet, practically at timber line. On the opposite side of the valley the limit was not more than 4000 feet.

Clearing weather revealed Whitemantle Range on the south side of Scar Creek. Its two main glaciers thrust their snouts into the creek valley at elevations of 2000 to 2500 feet, Stocking Glacier extending eastward and filling it so that drainage from other glaciers in the upper valley passes under the ice. It was hard to realize that these ice-panoplied peaks averaged only 8500 feet instead of at least 10,000.

An easy climb to Pivot Dome, elevation 6300 feet, opened to view the upper basin of Waddington Glacier, three to four miles wide and six miles long; it was, however, too crevassed to offer a ready route toward Mystery Mountain, which presumably lay beyond a pass between handsome peaks 10,000 and 11,000 feet in height, the pass being 9000.

Thicker weather next day proved disappointing on a climb to 9000 feet along the southern rim of Waddington Glacier. Bad snow and difficulties of a mountaineering nature prevented us from reaching the summit of Mt. Agur, 10,000 feet, south of the pass.[7] Rain held us in camp on June 20, but next day we moved camp westward across

[7] The name is suggested in honor of a member of the party who was subsequently killed in February, 1927, by being hurled over a cliff and buried by an avalanche in the mountains overlooking Vancouver, B. C.

FIG. 8

FIG. 9

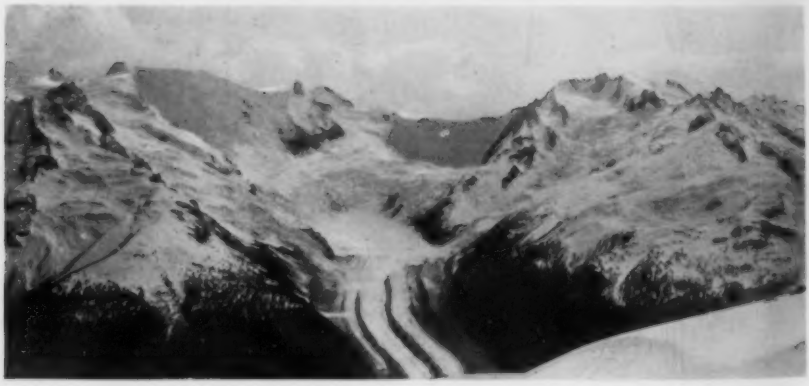


FIG. 10

FIG. 8—Part of Waddington Glacier and Scar Mountain (right), showing former course of glacier over right ridge. Homathko valley in distance. (Photograph by A. R. Munday.)

FIG. 9—Part of Scar Creek valley; Cascade Glacier at left, Stocking Glacier at right. (Photograph by A. R. Munday.)

FIG. 10—Mt. Whitemantle, Cascade Glacier, and Barb Mountain. (Photograph by A. R. Munday.)

FIG. 11

FIG. 12

FIG. 13

FIG. 11—Stocking Glacier from near camp in Avalanche valley. (Photograph by Mrs. Don Munday.)

FIG. 12—Avalanche Glacier; crest of icefall is 3000 feet above foreground. Note absence of glacier stream from snout; it flows behind moraine on left. (Photograph by A. R. Munday.)

FIG. 13—Mystery Pass at head of Waddington Glacier. (Photograph by A. R. Munday.)

FIG. 14—Looking down Tiedemann Glacier for 12 miles. (Photograph by A. R. Munday.)

three former glacial basins to Avalanche valley containing a glacier flowing south from the vicinity of Mt. Agur. Extensive avalanches had snapped off most trees about six feet above the ground. White avalanche lilies (*Erythronium montanum*) blossomed in profusion all around camp. Glimpses were obtained of a great glacier draining to Loughborough Inlet or Knight Inlet. The likelihood that it originated at the foot of the big mountain suggested that our goal was a considerable distance away.

MYSTERY PASS AND THE BIG MOUNTAIN

Clearing weather at last, an almost full moon, and the hope that night frost might improve snow conditions decided us to start on a final sortie—our supplies would not permit of more—on the evening of June 23. We took the pass east of Mt. Agur, whence we found a route down to a broad crevassed terrace. Dawn overtook us zigzagging tediously towards Mystery Pass. There, at 5.15 a. m., the big mountain opened to view at last. Miles of glacial valleys lay between. Its unassailable southern precipices were crowned with a still more forbidding spire tipped with a triple cornice of ice.

Descending into Ice valley we pushed on down the glacier to 7000 feet. The mountain did not improve on closer acquaintance. A hanging glacier guarded the western ridge, and the snow-crested eastern

one was barred by Spearmen Peak; but a traverse of this looked possible. We turned northward up a tributary glacier, troublesomely crevassed, all the way to the 10,000-foot col where, at 2.30 p. m., the sight of a hanging glacier on the hitherto hidden summit of Spearmen Peak spelled defeat.

FIG. 15—Lower pinnacles of Spearmen Peak, 11,000 feet, guarding base of east ridge of Mystery Mountain. (Photograph by A. R. Munday.)

From our position we looked eastward down Tiedemann Glacier for 15 miles—an enormous trench evenly floored with ice. The glacier is fed mainly by avalanches discharged four or five thousand feet directly upon it. Northeastward we saw far-off brown and nearly snowless foothills bordering the interior plateau. Southward through a notch we noted Victoria Peak, 7484 feet, the highest point on Vancouver Island. To the southwest extended what will doubtless prove to be the great glacier of the region. Only in two small distant areas did any wooded slopes appear.

Return was made approximately by the same route. Heavy crust on the snow made travel laborious, and camp was not reached till 4 a. m. The total elevation ascended in the 31-hour trip was 10,000 feet. Aneroid readings were checked with readings recorded three times a day at Bute Inlet during our absence.

Next morning in sleet and rain we broke camp and reached Coola Creek cache the same evening. The small amount of food there

allowed for no delays on the way down the river. Higher water in the valley impeded us greatly; in addition, Scar and Gorge creeks each cost us half a day. On July 1 the trapper's cabin was reached, hunger was at an end, and it was only a three hours' trip to McPhee's. From the inlet as we left we caught a brief glimpse of the great peak towering grandly over the intervening range at the head of Waddington Glacier and seeming to challenge our return.

Exploration of 1927

Exploration of the Mystery Mountain region in 1927 began with a preliminary trip by the writer and his wife to the head of Knight Inlet to investigate the source of the Franklin River. As suspected, this proved to be Mystery Glacier, seen in part the previous year. It descends to within 500 feet of sea level six miles from tidewater and is nearly half a mile wide at the snout. Ice is discharged from the snout in such quantities as to plow up the river bed and at times completely to dam the channels. The river has undermined the west margin for 400 years back from the forefoot and in July and August issued from a magnificent cave 150 feet wide. Knight Inlet has a wilder grandeur even than Bute.

Franklin valley is a glaciated gorge with walls rising from 3000 to 7000 feet. Flood channels of the river cover practically the whole valley floor. Two miles from salt water the vegetation begins to assume marked sub-alpine characteristics. Forest growth indicates that the glacier has retreated about a mile in the past 100 years, a series of short shrinkages usually intervening between long retreats. The ice has stood fully 500 feet above the present river bed.

The main trip was begun on July 18.[8] Engine trouble on Knight Inlet, high water on the Franklin, and trail-cutting delayed matters somewhat, and the combination of intense thawing at low altitudes and an intricate crevasse system on Mystery Glacier made its surface tediously rugged. Crampons proved absolutely essential on the ice.

By August 2 supplies had been relayed to a base camp at 4200 feet on the east side of the glacier and 11 miles from the mountain. A climb from here of a minor ridge 7500 feet high revealed the main features of the district and showed Mystery Glacier as probably covering fully 100 square miles, with Mystery Mountain and its intricate defending peaks clasped between the two main branches of the glacier.

The massive form of the mountain dominated the sky line, and the glacier dominated everything at lower levels. Below the forks the glacier turns an arc of 90 degrees around Icefall Point. At the same time it descends sharply for 500 feet in a magnificent and imposing

[8] The party consisted of the writer and his wife and her sister, Mrs. E. M. McCallum.

FIG. 16

FIG. 17

FIG. 16—Advanced stage of glacial sapping between two glaciers at base of Mt. Agur. (Photograph by Mrs. Don Munday.)

FIG. 17—Mystery Mountain across nameless glacier. (Photograph by Mrs. Don Munday.)

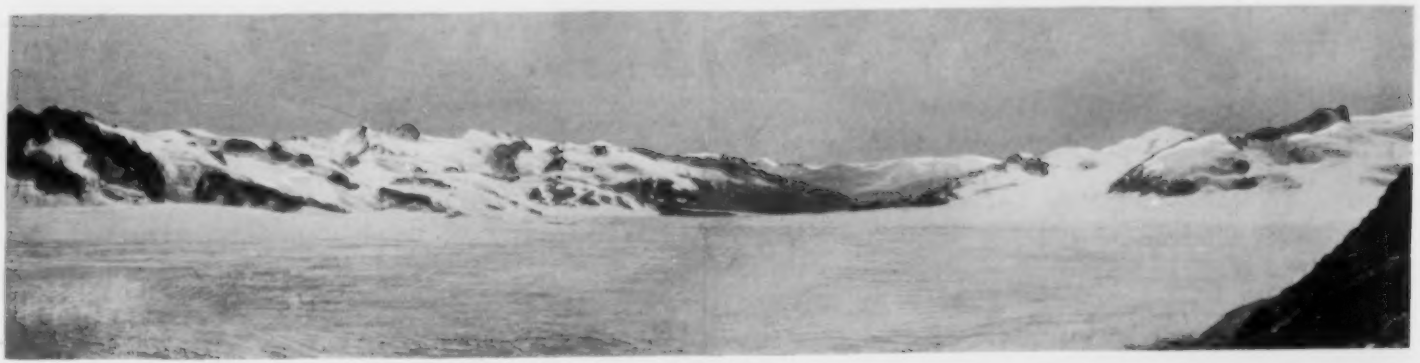


FIG. 18

FIG. 19

FIG. 20

FIG. 18—Looking down Mystery Glacier from fork of Mystery Glacier (southwest). Peaks in extreme distance on west side of head of Knight Inlet.
FIG. 19—Looking down east fork of Mystery Glacier from 10,000 feet on Mystery Mountain. (Photograph by Mrs. Don Munday.)
FIG. 20—8500-foot mountains along lower Mystery Glacier, from one of western tributaries, from elevation of 4500 feet.

icefall two miles in width, the splintered pinnacles maintaining orderly curving ranks which subside progressively to wavelike ridges of less and less prominence as they move down the glacier. On a lesser scale the east branch furnishes a similar spectacle where, after meeting the west branch almost end on and then being forced to describe a curve of 200 degrees, it is forced over the end of Glacier Island.

Ascent of the Mountain

This complex flow makes the glacier quite impassable for three miles; and so approach to Mystery Mountain was over Icefall Point on the west side of the glacier. The network of crevasses on the west branch was troublesome and at times not without danger. A shorter route was later discovered by traversing the icefall of a tributary glacier at risk of fusillades of ice from the impending masses above. From a bivouac at 7000 feet on a cliff edge, an elevation of 11,000 feet on a spur of the great west ridge was reached by noon. This climb was wisely abandoned—a rock fall of landslide proportions was witnessed across the only route of advance.

After a return to base camp the attack was transferred to the east ridge of the mountain from a bivouac at 7200 feet on cliffs on the west side of the east branch of the glacier. Masked, thinly-roofed longitudinal crevasses on the trunk glacier were negotiated in moonlight. An icefall of 2000 feet under the southeastern cliffs proved almost insurmountable. A rock wall of 10,500 feet could not be mastered, and the glacier was regained only at dusk.

The forbidding west ridge was then tried directly from its west base. It comprises 10 peaks from 10,000 to 11,500 feet high; and three of the highest were crossed in a climb to a height estimated at 13,000 feet, only 200 feet below the north summit. At 6.40 p. m., after 14 hours of climbing, an exceptionally violent electrical storm forced retreat over a route that had been difficult enough in the daylight.

Until August 29 the weather remained consistently poor, finally settling down to seven nights and six days of continuous rain, in the middle of which a creek three feet wide swelled in ten minutes at night to 100 feet and inundated camp. A few fine days followed, but the new snow made even the minor peaks unapproachable; and so further attempt on Mystery Mountain had to be abandoned until 1928.

Conclusion

The Coast Range has a general north-northwesterly trend from the Fraser River, but in the vicinity of latitude 51° for upwards of 100 miles it assumes a more westerly direction, and here are concentrated the maximum elevations of the range, carved into sharp jagged peaks out of the granitic rocks of the Coast Range batholith. Mystery Mountain is composed of schistose diorites, tilted to a nearly vertical

Fig. 19—Looking down east fork of Mystery Glacier from [illegible]
Fig. 20—8500-foot mountains along lower Mystery Glacier, from one of western tributaries, from elevation of 4500 feet.

position by a massive formation of lighter-colored granodiorite to the north; the Teidemann group is composed of this, the Teidemann Glacier following the contact in part. Part of this contact, however, is embodied in Mystery Mountain parallel to the summit ridge and close under the summit, the aplite-streaked schists everywhere attaining the highest elevation. They continue westward for at least 12 miles in formidable peaks ranging from 10,000 to 12,000 feet.

Glaciation, past and present, is notable for the vastness of its scale. The Homathko tongue of the Pleistocene ice sheet filled the valley to at least 5000 feet, imparting to the landscape all the typical features of intense glaciation; grooved and polished cliffs are still to be seen almost destitute of vegetation. A more recent stage of glaciation is recorded by huge ice-borne rocks in the river flats at Beaver and Gorge creeks. Between Scar and Coola creeks the river is deepening its channel through what has all the appearance of a morainal deposit across the valley.

Absence of surface moraines is most striking on Waddington Glacier, even the margin of the ice being clearly exposed down to within half a mile of the snout, and from thereon the covering is never thick. Absence of extensive areas of exposed rock around the snowfield account for the insignificant quantity of débris contained in the ice. Unfortunately time did not permit study of a series of ancient moraines on truncated spurs of Scar valley at 4500 feet and over.

As to the rate of recession of glaciers in the southern half of the Coast Range practically no information exists.[9] In estimating the age of recent moraines allowance ought to be made for the short period required for vegetation to gain a foothold owing to the moist climate of the Pacific slope. The average precipitation is 58.76 inches a year for Vancouver and 68.90 for Bute Inlet; but these figures probably have little bearing on the precipitation at higher levels of the range as a whole. In mountain valleys within 10 to 30 miles of Vancouver, and only a few hundred feet higher, the precipitation ranges from 80 to 138 inches a year. On the rainy west coast of northern Vancouver Island five stations give an average of 112.88 inches, and the lower elevation of the island mountains offers a lessened barrier to the sweep of the moisture-laden winds from the Pacific into the icy heart of the highest part of the Coast Range.

The valley of the Klinakline River, west of the Franklin, contains a partly explored glacier of vast size, descending to the same elevation as Mystery Glacier and probably covering an even greater area. West of the Klinakline River a peak has been triangulated as 11,714 feet, but its glacial surroundings are entirely unexplored.

[9] On the retreat of glaciers in similar latitudes of the Rockies see Howard Palmer: The Freshfield Glacier, Canadian Rockies, *Smithsonian Misc. Colls.*, Vol. 76, 1924, No. 11. Noted in *Geogr. Rev.*, Vol. 15, 1925, p. 302.

ASTRONOMICAL OBSERVATORIES IN THE MAYA AREA

Oliver Ricketson, Jr.

Carnegie Institution of Washington

THE oldest dated ruins so far discovered in the Maya area lie in the center of the northern portion of the Department of Petén, Guatemala. They were first reported by Dr. Sylvanus G. Morley in 1916 who named the site Uaxactun, a combination of two Maya words, *uaxac*, meaning eight, and *tun*, meaning stone. This name suggested itself, as Stela 9 in this city is inscribed with a date in the Maya calendric system equivalent to June 10, 68 A. D., the earliest date recorded on a monument contemporaneous with the occupation of the city that has yet been found in the New World.[1] The original Maya name of the city may never be known, so completely has the combination of time, a humid climate, and the ruthlessness of the Spanish *conquistadores* obliterated evidence pertaining to the once wide-spread Maya civilization. In 1925 the Government of Guatemala granted permission to the Carnegie Institution of Washington to carry out archeological investigations at this site.

Northern Petén and Routes Thither

Although we have every indication that the low-lying lands in the Petén District were once the seat of a dense and highly developed native population, today they constitute an almost inaccessible area, marked "Despoblado" on the maps. Except for a sparse population around the shores of the beautiful lake, Petén Itza, and on the picturesque island where Flores, the modern capital of the district, is situated, the northern part of the Petén is entirely destitute of inhabitants. North of Uaxactun stretches an unbroken wilderness, unexplored and unmapped, extending without interruption to the southernmost settlements in the states of Campeche and Quintana Roo, Mexico. A torrential tropical rainfall during eight or nine months of the year, which makes the ground beneath the dense jungle almost impassable, is followed by a three to four months season of great

[1] In the modern method of writing a Maya date it is 8.14.10.13.15 8 Men 8 Kayab, which means: 8 baktuns of 144,000 days each, 14 katuns of 7200 days each, 10 tuns of 360 days each, 13 uinals of 20 days each, 15 kins of 1 day each; bringing the count to the day 8 Men falling in the month Kayab on the eighth completed day. The correlation used is that of Herbert J. Spinden. The only two earlier dates are those of the Tuxtla Statuette, 8.6.2.4.17 8 Caban 0 Kankin, and the Leyden Plate, 8.14.3.1.12 1 Eb 0 Yaxkin, the former being, roughly, 168 years earlier, and the latter about 7 years earlier, than the Uaxactun date. Both of these earlier dates are carved on small, portable jadeite objects.

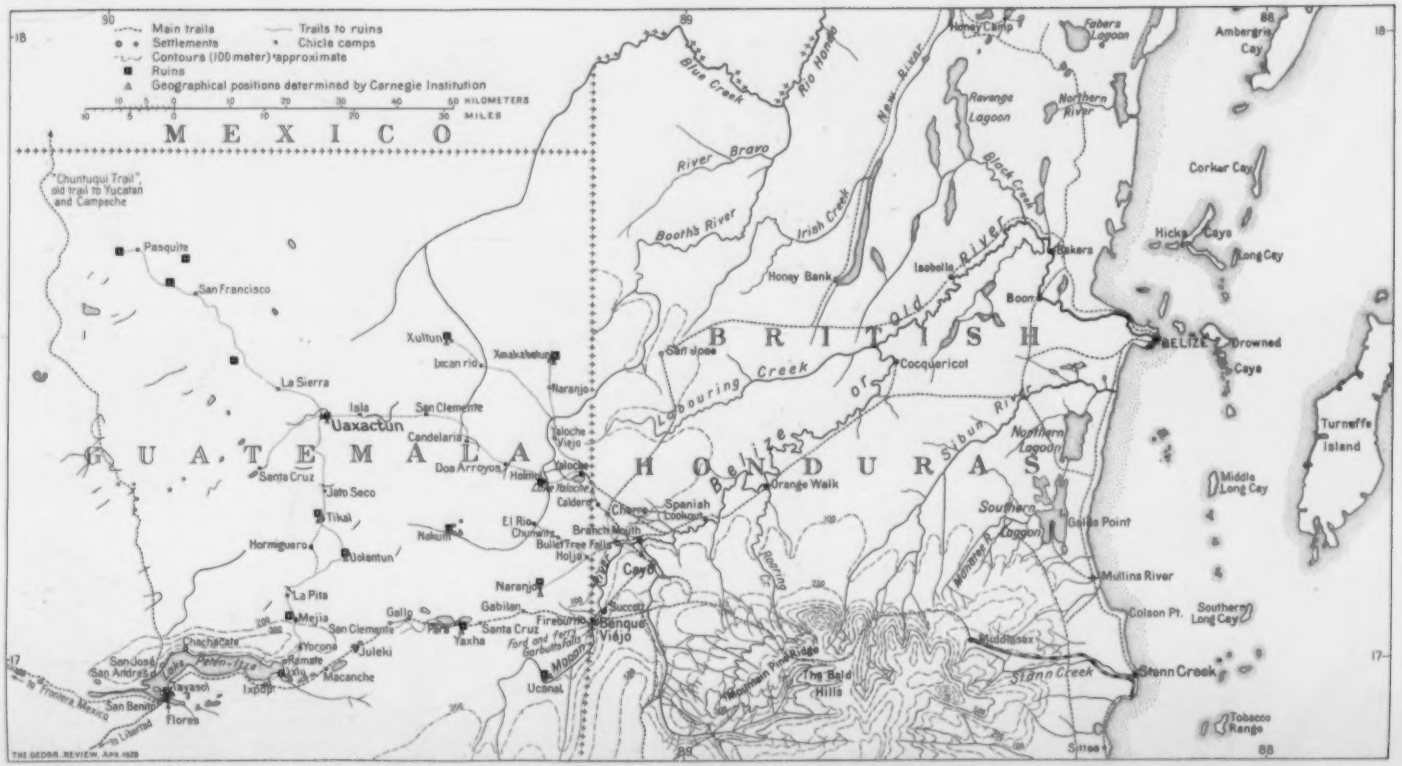


FIG. 1—Map showing the distribution of known Maya ruins in the Petén region of northeastern Guatemala and the chief approaches thereto. The Guatemalan section is based on a map of the chicle camps and trails of the P. W. Shufeldt Company (work of Captain Frank Vans Agnew and Didier Masson) with latitude and longitude of the ruins by the Carnegie Institution. All permanent sites in the Petén region as well as some temporary sites are included. Parallel rows of low hills run northeast and southwest with swamps (*bajos*) from one to five miles at the foot of the steep southerly slopes. There is no open country north and east of Petén: visibility in the jungle is well under 75 feet in any direction. Scale of the map approximately 1:1,300,000.

drought, when the traveler suffers from lack of water as much as he before suffered from a surplus. The rock is limestone, the drainage of the region subterranean; no springs and practically no streams or rivers are to be found. The remoteness of the gateways themselves from regular routes of travel, together with a relatively undeserved reputation for insalubrity and danger, is also a deterrent factor.

It is possible to reach northern Petén from four points: from Guatemala City overland by mule, ten to twenty days; from Frontera, Mexico, up the Usumacintla River to Paso Caballo on the Rio San Pedro Martyr; from Valladolid or Peto, Yucatan, overland by mule, a journey which few have ever attempted; and, lastly, from Belize, the capital of British Honduras. This last is the preferable route and is the one followed by the expeditions sent out by the Carnegie Institution of Washington.

Belize, the name of which is supposed to be an Hispanicized corruption of "Wallace," a seventeenth-century freebooter who there found fresh water and shelter between sorties against the treasure-laden galleons of Spain, is an hospitable town basking on the shores of the Caribbean. Here supplies and provisions of all sorts can be had, and a launch can be chartered for the ascent of the Belize River to El Cayo, the head of navigation, where mule trains are secured for the trip to the interior.

These river boats, drawing eighteen inches, are effective and unique. They are a local adaptation and are called "tunnel boats" because the propellor is countersunk in a well at the stern to prevent injury from rocks when the river is very low or the boat is passing through rapids. The tunnel boat usually carries a crew of eight or ten negroes and tows two "pitpans." These last are graceful barges of hand-hewn mahogany, about sixty feet long and wide enough to take a gasoline drum lengthwise. Each pitpan requires a steersman and two bow-boys with poles which are picturesquely called "milady sticks." These large crews are needed for navigation of the rapids encountered in the last two thirds of the trip, where frequently each unit of the "tow" has to be warped up separately. The ascent of the river takes from three to five days, sometimes longer if the water is low.

From El Cayo to Uaxactun is a three or four days' journey by mule. On an undersized beast, struggling through the gummy mud of logwood swamps and thorned vegetation, it is extremely trying. One never gets a view of open country, and both beast and rider are constantly attacked by an endless variety of insects. Seldom is it possible to cover more than twelve miles a day, and halts must be made where water holes are available, whether they lie three or six hours' distance apart.

But if the going is hard the ruins themselves are inspiring. Uaxactun, though by no means one of the greatest centers, completely

covers the artificially leveled top of a hill with a mass of temples and buildings and extends for several miles in each direction with two outlying groups reached by artificial causeways. In its well-paved plazas stand stone monuments bearing dates beginning with 68 A. D. and extending to 639 A. D.—five hundred and seventy-one years of

FIG. 2

FIG. 3

FIG. 2—Looking west across the Plaza of Group E, Uaxactun, Guatemala. Temple VII is shown with location of stairway and masks. Stela No. 20 can be seen directly in front. (Courtesy of the Carnegie Institution.)

FIG. 3—The Plaza, Group E. Looking east at Stela No. 19 and main stairway in front of Temple E II. (Courtesy of the Carnegie Institution.)

continuous occupancy at the very least. How long the city was settled before the Maya carved their dates on stone no one has ventured to guess, much less how long a period must have elapsed before their extraordinary calendric system was finally developed. This system breaks upon our view in full flower, the characters already conventionalized and carved upon stone.

ASTRONOMICAL OBSERVATORIES: THE CARACOL

We now have at least two bits of evidence as to how the Maya went about making their astronomic observations. The first of these occurs in the building called the "Caracol," at Chichen Itza, Yucatan; the second is the so-called "Solar Observatory" at Uaxactun.

The Caracol is a circular tower with four outer doors facing the cardinal points of the compass.[2] Within is a circular corridor from which four more doors, facing midway between the cardinal points, lead into another circular corridor. This inner circular corridor surrounds a masonry core, inside which a small, spiral staircase leads

FIG. 4

FIG. 5

FIG. 4—Glyph blocks on Stela No. 18, Group E, Uaxactun, Guatemala. This monument bears the date 8.16.0.0.0 3 Ahau 8 Kankin, or April 5, 97 A. D. in our chronology. (Courtesy of the Carnegie Institution.)

FIG. 5—Uaxactun, Guatemala. Group E. Closer view of primary temple, with masks, found on Mound E VII. Looking west. (Courtesy of the Carnegie Institution.)

to the upper part of the building. Unfortunately, the upper terminus of the stairway cannot be ascertained, for, a little more than halfway to the top, the whole northern section of the building has completely fallen. Near the top of the structure is a flat area from which open three rectangular, horizontal shafts known as *ventanas*, or windows. The largest of these, Window 1, faces west and was until recently the only one known. Windows 2 and 3, uncovered during the repair of the building in 1925 by the Chichen Itza Project of the Carnegie Institution, face southwest and south, respectively. Figure 6 (not drawn to scale) shows their relative position and directions.

[2] W. H. Holmes, "Archeological Studies among the Ancient Cities of Mexico," *Field Museum of Nat. Hist. Publ. 8 (Anthropol. Ser., Vol. 1, No. 1)*, 1895, illustrates the structure very completely: see pp. 115–120.

It is the writer's belief that these three windows opened from a rectangular room to which the hidden spiral stairway gave access. There may have been other windows, but in this regard nothing can be stated with certainty, as the northern and eastern sections have completely fallen. In regard to the results obtained from careful measurements of the three windows still *in situ*, however, there can be no doubt. The directions of these windows and of their diagonals were taken with a Brunton compass, and the data were submitted to the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, with a mere suggestion that the important lines of sight were not the actual directions of the windows themselves but of their diagonals. Their findings are best described in a letter from Dr. Louis A. Bauer, Director of the Department of Terrestrial Magnetism, from which I will quote:

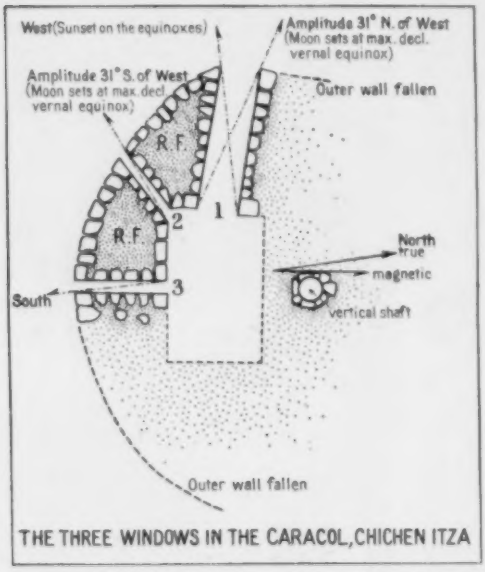


FIG. 6—Diagram of the three windows in the Caracol, Chichen Itza. The location of probable observer's room is indicated by a dashed line. The windows or shafts are numbered 1, 2, and 3. R. F. is the rubble fill of stone faced walls. (Courtesy of the Carnegie Institution.)

. . . I inclose a diagram of directions or azimuths of the sun and moon at the time of their setting at Chichen Itza when their declinations for the year are greatest; also a tracing to fit over the diagram, showing the azimuths of the windows and their respective jambs.

In the following notes the jambs are designated *right* and *left* as when *looking out*, and azimuths or directions are astronomical:

a. Window 1. The direction, *right inner* jamb to *left outer* jamb, is *due west*.
b. Window 3. The direction, *right inner* jamb to *left outer* jamb, is *due south*.
c. Window 2. The direction, *left inner* jamb to *right outer* jamb, is in azimuth 59 reckoned westward from south, or in *amplitude 31*.
d. Window 1. The direction, *left inner* jamb to *right outer* jamb, has the same amplitude north of west (31) as *c* is south of west.

The amplitude of the sun at setting on March 21 was 0°, or due west, which accords with the direction under *a*.

The directions *c* and *d* are the directions of the moon at setting when its ascending node is in the vernal equinox; that is when its declination is a maximum, about 28° 36′. Nothing apparently marks the direction of its setting nine and a half years later, when its maximum declination for the year is reduced to about 18° 25′ and its amplitudes become 20° north or south.

FIG. 7

FIG. 8

FIG. 7—Temples E I, E II, and E III as seen from the northwest. Stelae Nos. 18 and 19 are just at the base of the substructure platform, to the right. (Courtesy of the Carnegie Institution.)

FIG. 8—A view of Temple E II looking south from Temple E I after excavation. The damaged condition of the masonry is evident. (Courtesy of the Carnegie Institution.)

Window 3 is not high enough for direct observations of the sun at noon or the moon at meridian passages; hence, if it was constructed for such observations, it must have been the shadows of the jambs cast by the sun or moon that were noted.

Directions *a*, *b*, *c*, and *d* mark astronomical directions of local importance, whether intentionally or unwittingly; but two directions remain for which I can assign no reason at the present time.

The Uaxactun Observatory

These truly remarkable results seem the more significant when considered in connection with work done along the same lines at Uaxactun. Since the discovery of Uaxactun in 1916 it has been visited by several expeditions sent out by the Carnegie Institution of Washington. In 1923 the seventh Central American expedition, under the direction of the writer and Mr. Witherow Love of the Department of Terrestrial Magnetism, spent several months in the Petén District locating the exact geographic positions by latitude and longitude of twelve important ruins, of which Uaxactun was one. In 1924 the eighth expedition, directed by Mr. Frans Blom, made an accurate plane-table survey of the city. Although no excavation was possible at that time, Mr. Blom drew attention to the fact that the arrangement of buildings, mounds, and stelae in the easternmost plaza, called Group E on his map, suggested its probable function as a solar observatory

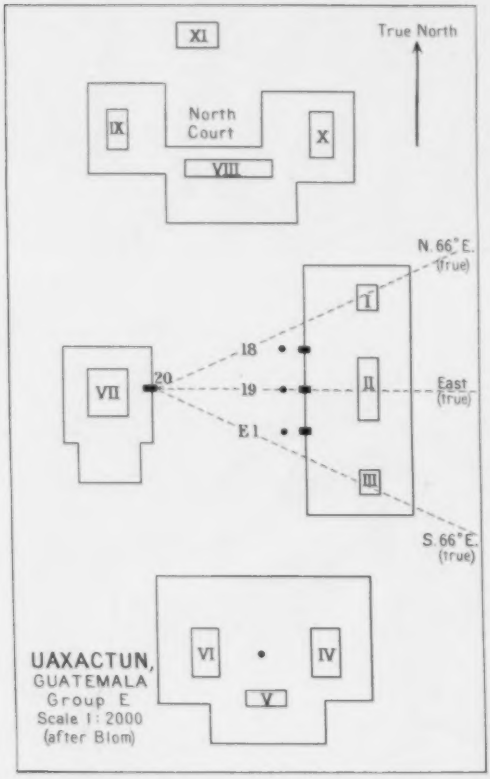


FIG. 9—Ground plan of Group E, Uaxactun, before excavation. After Blom. (Courtesy of the Carnegie Institution.)

The ground plan of this group, as it appeared before excavation, is shown in Figure 9. Making his observations from Stela 20 as he faced the east, Mr. Blom noted that the true east-west line passed through the estimated center of Mound E II, and that lines drawn to the apparent centers of Mounds E I and E III were 24° north and

south of the true east-west line. The geographic position of Uaxactun having been determined the year before, it was possible to determine both the magnetic declination of the compass and the amplitudes of the sunrise points for that location. The latter were found to be 24.4°

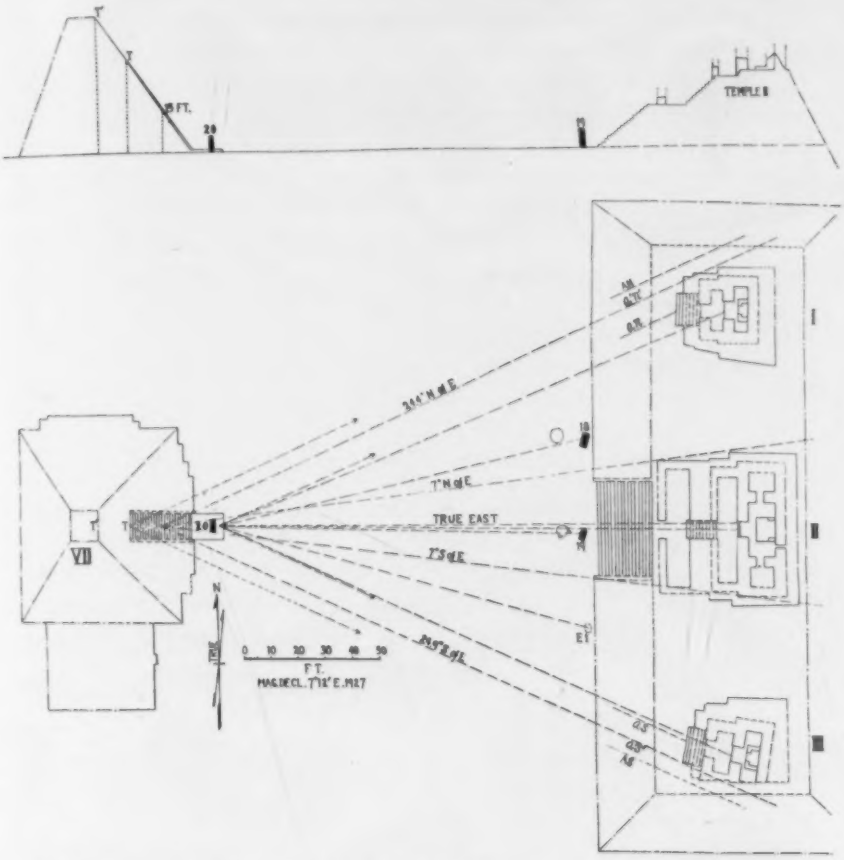


FIG. 10—Ground plan of Temples E I, E II, and E VII, at Uaxactun, as excavated in 1927. Above the plan is a cross section along an east-west line. (Courtesy of the Carnegie Institution.)

north of east and 24.9° south of east (visible horizon) on June 22 and December 22 respectively—i. e. the summer and the winter solstices. The true east-west line gave, of course, the position of sunrise on both the vernal and autumnal equinoxes.

When excavation was begun in 1926, under the direction of the writer, this group was selected for investigation. The results of two seasons' work are summarized in Figure 10. Mounds E I, E II, and E III were found to be temples, the floor levels of which lay ten feet above the substructure platform which underlies all three of them. This substructure platform is fifteen feet above the plaza level. The

true east-west line passes just within the north jamb of the doorway of Temple E II and up the mid-line of the stone stairway which was found on the east slope of Mound E VII. The directions for the amplitudes of the sun on June 22 and December 22 were found to strike the front steps of Temples E I and E respectively if taken from Stela 20. These directions are shown on Figure 10 as the lines *a n* and *a s*. But, because of the fifteen-foot substructure platform beneath Temples E I, E II, and E III, no observations of sunrise points on the horizon could possibly be made from the plaza level, and as a point of observation Stela 20 has to be abandoned. The directions taken from the top of the stairway on Mound E VII pass too far outside the limits of Temples E I and E III. They are shown in Figure 10 as lines *A N* and *A S*. But from a point fifteen feet vertically above plaza level on the mid-line of the stairway on Mound E VII the same directions give the lines *a' n'* and *a' s'*, which just touch the corners of Temples E I and E III respectively. This point was arbitrarily chosen because it is the lowest possible point from which a view could be had of the horizon over the fifteen-foot substructure mound.

Significant Dates in the Maya Calendar

The angles subtended by Temple E II from this point were then examined. Because of the dilapidated condition of this temple one wall alone could be located with sufficient precision for the necessary measurements. This was on the northwest corner of the temple platform and fortunately proved quite enough for the purpose, since the temple walls proper must have stood inside the point thus indicated. The bearing of this corner was found to be 7° north of east, and this direction was submitted to the Department of Terrestrial Magnetism for analysis. The Department replied that the directions 7° north and south of the true east-west line were apparently of no astronomic significance for Uaxactun; they merely marked the points of sunrise on March 3 and April 6 to the north and September 6 and October 10 to the south. These dates, however, have considerable significance in the Maya calendric system. They occur repeatedly on monuments throughout the entire area, especially the April 6 and September 6 dates; and, if we examine the three stelae standing in the plaza of Group E in Uaxactun, we find the following interesting approximations:

Stela 18	8.16.0.0.0	3 Ahau	8 Kankin	April 5, 97 A.D.
Stela 19	8.16.0.0.0	3 Ahau	8 Kankin	April 5, 97 A.D.
Stela 20	9. 3.0.0.0	2 Ahau	18 Muan	April 3, 235 A.D.

As the point on Temple E II used in this calculation is the most northerly point possible, being a well-defined corner of the platform beneath the temple, the temple walls must lie to the south of it, or towards April 5 and April 3, the dates on the stelae in this group.

It is interesting to note in this connection that Dr. Spinden in his book "The Reduction of Mayan Dates" reaches a conclusion not too dissimilar regarding the two famous "Piedras Pintadas" at Copan, Honduras.[3] These two stelae, four and a half miles apart across a valley, Stela 12 located on the east and Stela 10 on the crest of a hill to the west, have long been considered as a possible astronomical base line. Stela 12 bears two dates:

9.10.15.0.0	6 Ahau 13 Mac	January	11, 388 A.D.
9.11. 0.0.0	12 Ahau 8 Ceh	December	15, 392 A.D.

and Stela 10 bears the date:

9.10.19.13.0	3 Ahau 8 Yaxkin	September	6, 392 A.D.

Dr. Spinden supposes that the line of sunset originally established between these two monuments occurred on September 6 and its reciprocal April 5 and that later this line was shifted, presumably by moving Stela 10 to the north, so that it marked the line of sunset on April 9 and September 2. On Altar U at Copan the following dates probably record this change:

9.15. 8.10.12	2 Eb	0 Pop	April	9, 480 A.D.
9.15. 9. 0. 2	9 Ik	10 Mol	September	6, 480 A.D.
9.15. 9.10.17	3 Caban	0 Pop	April	9, 481 A.D.
9.16.12. 5.17	6 Caban	10 Mol	September	2, 503 A.D.

Dr. Spinden also cites many other inscriptions in support of this argument.

Dr. Morley is of the opinion, though he advances it necessarily without proof, that the April dates marked religious festivals connected with the beginning of the agricultural year. This theory presupposes that the ancient Maya practiced the "milpa" system of agriculture which is in use throughout the region today. This system consists in felling the jungle at the beginning of the dry season, burning it during April, and planting shortly thereafter at the beginning of the rains. Whether "milpa" agriculture, with its attendant waste of land, could have supported a dense population is debatable.

More work of this sort in the field and in the study will undoubtedly prove of value as a means toward the complete decipherment of the Maya hieroglyphs and a better understanding of their relationship to Maya civilization in general. It is sincerely to be hoped that all investigators in this field, whether visiting old sites or exploring new ones, will take accurate and copious bearings whenever the opportunity offers or the faintest suspicion arises that the arrangement of buildings or structural features may have been designed in accordance with astronomical directions.

[3] H. J. Spinden: The Reduction of Mayan Dates, *Papers Peabody Museum of Amer. Archaeology and Ethnology*, Vol. 6, No. 4, Cambridge, Mass., 1924.

AN AMERICAN COLONY IN BRAZIL*

Mark Jefferson

FIG. 1—Brazilian grandson of a Confederate veteran.

THIS youngster, of unmixed blood of Georgia whites, was born within fifty miles of São Paulo, Brazil, like his father and mother before him and probably speaks the Portuguese of Brazil more easily than the English of the United States. He is a Brazilian and will do his military service in the Brazilian army when he comes of age. I think he counts himself American in spite of his established legal nationality. So do both his parents. The country of his birth may never win his heart. It may be his good fortune later to go away to the States to college for a year or two. He will come back with better English but still English with a Brazilian accent. Brazil cannot be said to have assimilated him. Blood and home associations speak to him of American Georgia as definitely as does the chimney of his father's cottage, singular excrescence on a tile-roofed house in São Paulo; but among the Americans in the hills of Villa Americana all the houses have chimneys and other features incongruous in a Brazilian countryside, such as windows with sliding sashes and wooden shutters, eaves troughs and water conductors, a two-story veranda and a wooden picket fence, as in this house of a neighbor (Fig. 3), a bit of the southern Confederacy set down in Brazil.

EMIGRATION FOLLOWING THE CIVIL WAR

In general the United States has had few emigrants, but Lee's surrender found many in the South unable to endure existence in a country where abolition and the hated Yankee had come out victorious. Lordly men they had been, the wealthier Southerners. With numerous slaves indoors and out to attend their wishes, these men lived like princes. Great numbers of them looked for new homes. Unrest in the South was indeed older than the Confederacy. There were those

* From field notes of Dr. Alfred Coester, of the American Geographical Society's Expedition to A B C Countries in 1918.

Southerners who had gone into Mexican Texas with their slaves and "kept them still when Mexico, in 1824, abolished slavery." Certainly the end of the war in 1865 turned the eyes of many a last-ditch rebel to Mexico and Brazil, where slaves could still be held.

The government of Brazil had been very keen for their coming. Every Latin American country that has fostered immigration has cherished the illusion that immigrants from the United States might be obtained and has desired them in spite of our little popularity there as a nation. The Latin American countries admire the intelligent capacity for action of our citizens and would gladly incorporate many of them among their own nationals. Their desire proved illusory because none of them ever offered the attraction of the American Homestead Law, while the scale of living of the laboring man in Latin America is far below anything that white men have to put up with in the United States. The defeat of the Confederacy gave Brazil her opportunity. Slavery was not finally abolished in that country till 1888. In Brazil the confederates could have slaves and could also, they thought, grow cotton. It seemed a likely place to continue the old life of the South. Doubtless that was the picture held before Southern families by the agents of the Brazilian government in New York, who contracted with a steamship company for transportation from that point to Brazil and advanced railway fares from points of origin in the Southern states, later shifting the point of embarkation from New York to Mobile and New Orleans.[1]

Captain Richard F. Burton was in Brazil at the time and expected great results to flow from the immigration of Confederates to the Empire.[2] He gives the number of arrivals from the States for 1867 as 2700 persons: 200 in Paraná, 800 in São Paulo, 200 in Rio Janeiro, 100 in Minas Gerães, 400 in Espirito Santo, 100 in Bahía, 70 in Pernambuco, and 200 in Pará, Southerners who had, he says "exchanged their desolate homes for happier regions." The 200 settlers in Paraná were "principally Missourians, who come with considerable capital, and who in a few years will make this centre very important." Captain Burton looked to see a great exodus of "the lower orders of Englishmen, which word includes Irishmen" . . . . "and when Southerners from the United States shall have settled in the Empire, these men, so well accustomed at home to 'drive' whites and to deal with the *prolétaires* and the *colluvies gentium* of Europe, will soon supply the necessary curb."

The outcome has not, however, justified expectations so high. These "unsubmitting Rebels," says Roy Nash,[3] "made small mark

[1] Compare Lawrence F. Hill: Confederate Exiles to Brazil, *Hispanic Amer. Hist. Rev.*, Vol. 7, 1927, pp. 192–210.

[2] R. F. Burton: Explorations of the Highlands of the Brazil (2 vols., London, 1869), Vol. 1, pp. 5–9.

[3] Roy Nash: The Conquest of Brazil, New York, 1926, p. 152.

upon Brazil, but Brazil certainly put her stamp upon them and their descendants. They had gone to the wrong place." Of the 200 settlers in Pará, near Santarem, there were fifty left in 1874 when Herbert Smith found them, "people from Tennessee, Mississippi, and Alabama who knew how the frontier game should be played; lean, hard men with their wives and children, men who had come to stay." But they were "burdened with debts, living in squalor, with broken-down bodies and discouraged hearts." Now in 1926 "there are not more than twelve or fifteen left, including the second generation! The only North American in that Santarém colony who can be said to have made a success was a man who started with a very considerable capital."[4]

The Villa Americana Group

It appears that the group who settled about Villa Americana were among the most successful of all who came to Brazil from the United States. They had started originally for Mexico and had traveled as far as New Orleans when they learned of the death of Maximilian and changed their destination to Brazil.

At first they were landed at Cananea and settled at Iguape, about 100 miles south of Santos in the low country near the coast. In fact two Americans naturalized in Brazil had gone from Iguapé to New York on the government mission to collect immigrants in the States. But the hot, jungly country of the coast did not suit the settlers at all. Within three months the two hundred families that had landed here began to scatter to higher ground. At the end of three years half of them had gone back to North America, and none of them were left near Cananea. At Santa Barbara, on the plateau 70 miles in a direct line northeast of São Paulo, they found conditions to their liking; "better than western Florida or southern Georgia" said one of them. "A white man can work out on the hills in the hottest months. I have done it." This is near the southern border of the torrid zone but at an elevation of 2700 feet above the sea. The hottest month of 1916 showed no temperature at São Paulo as high as 90° with nights in the 60's. Half the time the afternoon temperature failed to rise above 80°, while the winter temperatures rarely fell below 50°.[5]

The Southerners could have slaves, of course, those who had money to buy them, though few did; and they went to raising cotton at once. When the crop was harvested they discovered that there was little demand for cotton, a low price, and no profit in raising it. The older heads of families today admit that they would have done better if they had stayed at home in the States, and the younger people are even more persuaded of it than their elders. Some of them went into the

[4] *Ibid.*, p. 386.

[5] Mark Jefferson: Actual Temperatures of South America, *Geogr. Rev.*, Vol. 16, 1926, pp. 443-466; reference on p. 456.

raising of sugar cane and the distillation of "pinga," or rum, for which the market was almost infinite. One at least of the party made a fortune at it.

Two bits of good fortune came their way: cheap land and an American watermelon. The hills about Santa Barbara had been cleared of forest and cultivated in the manner of Brazilian hoe culture but were now grown up with *sape*, a sort of scrub plant that could not be killed with the hoe. They were therefore regarded as worthless and sold to the Southerners very cheaply. But the plows the Americans brought with them killed the *sape* easily, and the land proved excellent. By this chance the healthful, rolling hills became the site of the farms of the Georgians. One of them likes to tell how he earned the money for his farm by three years labor for a richer neighbor at 25 milreis a month when the milreis was worth 50 American cents. So they did find in Brazil something like homestead land after all. But this mainly enabled them to raise their food and live. There was no money crop until one of them, visiting "back home," brought out some watermelon seed from Georgia that made a wonderful hit in the Brazilian countryside. This must have been about 1878.

At first the Americans took their melons to neighboring towns, where they found ready sale. They were so much pre-

FIG. 2

FIG. 3

FIG. 4

FIG. 2—Brazilian house with American chimney, Villa Americana.

FIG. 3—"American house" of Dr. Hall, Villa Americana. Note chimney, windows, and shutters.

FIG. 4—House at Villa Americana built by Dr. Pyles' father, mostly with his own hands. Backyard view. Note the chimney and patchwork quilt.

ferred by the Brazilians to their own watermelons that buyers soon began to come to the Americans from far and near. For a season of three months 50 to 100 carloads of watermelons a day were shipped out of Santa Barbara by rail; the broad street near the station was always crowded with carts, and the freight yard was piled high with the crop. One of the Italians who owned land at the station got the name of it changed to Villa Americana. For twenty-five years the business lasted and was the basis of general prosperity for the American colonists. The most profitable period was from 1890 to 1900. Finally the soil became exhausted, and the Italians who had come into the neighborhood took up the business on fresh land. The Americans agree in hating the Italians!

FIG. 5—Veteran settler of 1867 in his buckboard at Villa Americana in 1918. Frost is not common, but that year it killed the bananas.

THE PRESENT SITUATION OF THE COLONY

That has been the only general success registered by the Americans. They raised their food easily enough and something for a money crop but were apt to become Brazilianized, as they put it, which seems to mean lazy, shiftless, and content to get along on little. The colony is not expected to endure. It may be said to be passing away already, for the schools and churches set up by the Americans in the early days to preserve their institutions have ceased to exist. Children are now sent to the States, if the parents can afford it, or to private schools in São Paulo. The Americans feel that the end comes when marriage occurs with Brazilians, for then the children become Brazilians too. But very little of this has occurred in this neighborhood; there were no Brazilians here to marry! The colony will come to an end by scattering to the cities or other parts of the country, where the more capable find opportunities better suited to their capacity. One uncle of our young Brazilian went to Rio Janeiro, where he is regarded as the most eminent surgeon in the city. Another grandson of a Confederate veteran of Villa Americana, in 1918, had just settled up his father's estate, had sold the house, and was leaving to join a brother on a cattle ranch in the western part of Rio Grande do Sul, prosperous

in this world's goods but saddened by the unwelcome conviction that he must confess himself a Brazilian. He had been to the States in the attempt to establish American citizenship and had been denied it.

The only Brazilians the Americans of Villa Americana came in contact with are of so low a social stratum that Brazilian is a word of contempt in the colony, much as it is at Joinville.[6] The operation of the "melting pot" that has transformed so many European peasants into new men in the United States has been opportunity to rise above a previous lowly condition. This was provided in the United States by free homesteads and opportunity in trade and industry. By continuous application of the habits of thrift and industry they brought with them the European peasants rise with relative certainty to a condition above anything the old world can offer them, and their contentment with their new home grows. The American colonists in Brazil found no such novel opportunity. Economically and socially they had been better off in Georgia than most of them ever were in Brazil. In fact only the two happy circumstances mentioned had saved them from the misfortunes that attended most of the parties of Americans. For the rest Brazil offered them only slavery—until 1888—and slavery proved no panacea. It does not appear to have been of any use to them, though they gave up much to secure it. Brazil, on the other hand, gained from their coming in their immediate localities. Of this the plow factory at Villa Americana in a hoe-culture countryside is an evidence. The infusion of American blood in the Brazilian race was worth while too, but both items are small in the vastness of Brazil.

It does not appear that the Americans greatly influenced their fellow colonists, the Italians, except in breaking the *sape* with the plow and the culture of the watermelons. There was little social contact. The buckboard, admirably adapted to this rough country, is still in use by the Americans but has not been adopted by their neighbors. But in the cities to which the Americans mostly drift they add a most desirable element to Brazilian society into which they are likely to be promptly amalgamated.

[6] Mark Jefferson: Pictures from Southern Brazil, *Geogr. Rev.*, Vol. 16, 1926, pp. 521–547.

EXPLORATION OF THE WATERS OF THE GULF OF MAINE

Henry B. Bigelow

Museum of Comparative Zoölogy, Cambridge, Mass.

THE warm, sapphire-blue Gulf Stream with its tropical freight, on the one hand, and the receding coast lines of Nova Scotia, Maine, and Massachusetts on the other, enclose the cool, green waters of the Gulf of Maine. Partially enclosed by the Banks, Georges and Browns, that form its shallow offshore rim and largely protected from the tropic water it faces by the peculiar distribution of densities along the arc of its seaward front, the Gulf is a sort of backwater from the Atlantic. Here the cod, haddock, pollock, herring, and all the other fish that make up the 400-odd-million pounds of sea food it yields to man every year play their rôles, inured to seasonal fluctuations but seldom suffering any fatal variation in temperature.

The Gulf may well be named a "promised land" for its inhabitants; it is equable in climate and moderate in salinity; its deeps are constant from season to season; and it is well supplied with food, whether animate or dissolved. In all of which our Gulf is comparable with the North Sea across the Atlantic.

No doubt for this very reason, because it is less spectacular than the Gulf Stream across its offshore portal, less stirring to the imagination than the ocean abyss, none of the major deep-sea expeditions have so much as entered the Gulf of Maine. The earlier collecting expeditions of the U. S. Bureau of Fisheries, in the seventies and eighties of the past century, did, it is true, record serial temperatures in its western side in summer. However, knowledge of the saltness of its waters; of their temperatures at other times and places; of their dominant circulation; and of the plankton they support, might still be hazy but for the growing appreciation that it is in the shoaler seas and in moderately high latitudes that the physical, chemical, and biologic problems most vital in the life chain in the sea are best attacked.

The study of marine ecology in the modern sense, which first gathered momentum in northern Europe under the auspices of the International Committee for the exploration of the sea, has now become widely extended. In the summer of 1912, as a step in its progress, the Museum of Comparative Zoölogy and the U. S. Bureau of Fisheries in coöperation began a detailed exploration of the oceanic biology and physical oceanography of the offshore waters of the Gulf of Maine.

This preliminary survey may now fairly be described as completed with the publication of the final part of the general report, making timely a brief summary of the progress of the undertaking and of its more directly geographic results.[1]

The value of any such study of a given part of the sea depends very largely on the thoroughness of the exploration. It was realized from the beginning that all seasons of the year must be covered, since seasonal fluctuations would be wide, both in the temperature and salinity of the water and in its biology. Equally, the survey must be extended over a considerable period of years (at least at certain places) to take account of the annual fluctuations which there was every reason to expect. And it was obvious that, for an understanding of the internal problems of the Gulf, the state of the coastal waters to the east and west of it and of the inner edge of the Gulf Stream offshore, must also be examined. But it was necessary to begin on a small scale, increasing our modest outfit, and extending the cruises in duration from year to year, as the increasing significance of the scientific harvest seemed to warrant.

Our work has consisted mostly in the taking of serial records (surface to bottom) of the temperatures and of the salinity of the water; combined with an extensive program of tow nettings, shoal and deep, at stations scattered netlike over the Gulf and so placed as to yield both horizontal projections and a variety of profiles.

The Temperature of the Water in the Gulf of Maine

Of the several physical features of the sea water, its temperature is the most important biologically, for this determines what general communities of animals (plants in less degree) can survive in any particular part of the ocean, granted that such other factors as light, food, salinity, alkalinity, etc., favor their existence.

The temperature of the water in any part of the sea is controlled by the interplay of two processes. One is the transport thither of warm water or of cold from elsewhere by the flow of ocean currents, which may raise the local temperature above the mean for its latitude, as happens along the coasts of northern Norway, or chill it below, as in the Labrador Current skirting southward past Newfoundland and the Grand Banks. The other factor is the interaction between solar warming *in situ*, on the one hand and cooling by evaporation and radiation on the other.

It has long been known that the Gulf is boreal in temperature, its mean surface value (which we can now set at about 7° to 8°) being several degrees lower than the mean for the Atlantic as a whole at

[1] *U. S. Bureau of Fisheries, Bull. 40.* Preliminary accounts of the work have appeared from time to time in *Science* (Vol. 38, N. S., pp. 599–601) and in the Bulletins of the Museum of Comparative Zoölogy (Vol. 58, 1912, pp. 31–144; Vol. 58, 1914, pp. 383–420; Vol. 59, 1915, pp. 149–360; Vol. 61, 1917, pp. 161–358; Vol. 65, 1922, pp. 85–188.

its latitude (between 13° and 14° C.). To this we can add that a much greater discrepancy of the same sort prevails between the deeps of the Gulf—100 meters and deeper—and the corresponding depth zone of the open oceans at the same latitude. Until the present exploration was undertaken it was the generally accepted belief that the Gulf of Maine owed its low temperature directly to an Arctic current. Perhaps the most instructive result of the cruises has been the demonstration that this is not the case. Although cold water from a more northern source does pour into the Gulf from the east every spring, it is the local influences just mentioned, combined with an indraft of water over the bottom from the edge of the continent, that chiefly determine the local temperature.

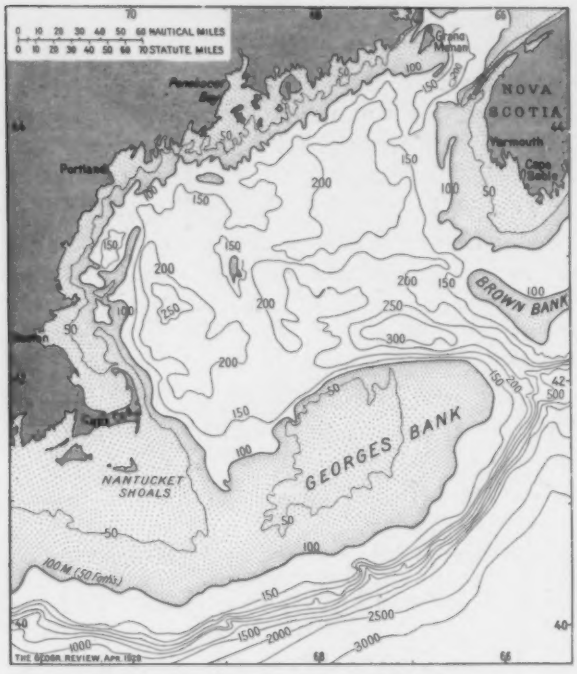


FIG. 1—Bottom contour of the Gulf of Maine, based on Hydrographic Office Chart 941. Depths in meters.

Thus if the Gulf may seem to lose interest from one point of view, it gains from another, as offering an opportunity to trace the seasonal alterations which follow potent solar warming during the warm months, alternating with a rapid loss of heat by radiation during the cold. Equally instructive has been the correlation between areas of cold surface and of violent tidal churning, for it is where the latter is most active that the supply of dissolved foodstuffs is most constantly renewed in the upper stratum, making conditions most favorable for marine plants and, in turn, for the animals that feed thereon. Evidence of this appears in the concentration of the "sardine" sized herring in the tide-swept and homogeneous waters of Passamaquoddy Bay and among the islands along the eastern sector of the coast of Maine.

On the chart the Gulf of Maine is simply an open bight. But when the contour of the bottom (Fig. 1) is taken into account it be-

comes a far more definitely limited area, for its ocean front takes the form of a rim (Nantucket Shoals, Georges and Browns Banks) so shoal that at a depth of 100 meters the basin of the Gulf within is entirely enclosed except for two narrow passages. These are the Eastern Channel, opening to the southeast between Georges and Browns Banks, and the shoaler Northern Channel, lying between the latter and the coastal slope of Nova Scotia. Topographically, then, the Gulf may without much exaggeration be considered mediterranean, or landlocked. Whether the water within a bowl of this sort be colder than off its mouth, as is the case in the Gulf of Maine, or warmer, as in the Red Sea, depends on the local thermal determinants. In the Gulf of Maine we have a low temperature due to winter chilling plus cold water from the north and east, contrasted with almost tropic temperatures offshore. How effectively the rim actually separates the deeper strata of the bowl on the one hand from the inner edge of the Gulf Stream on the other may be illustrated by the summer profile of temperature, running out from the offing of Cape Cod, southward across Georges Bank (Fig. 2). While the surface of the western side of the Gulf may warm, under the summer sun, to a value approaching that of the tropic water offshore (18°–20°), to find temperatures over the continental slope as cold as is the 100-meter level within the Gulf (4°–5°) it is necessary to sink deeper than 500 meters, i. e. down almost to the upper boundary of the nearly homogeneous water of the oceanic abyss. So abrupt a transition between low temperatures on the continental shelf and very much warmer temperatures only a few miles offshore all along the northeast American seaboard to the Grand Banks, even where there is nothing in the contour of the bottom to prevent interchange in the one direction or in the other,

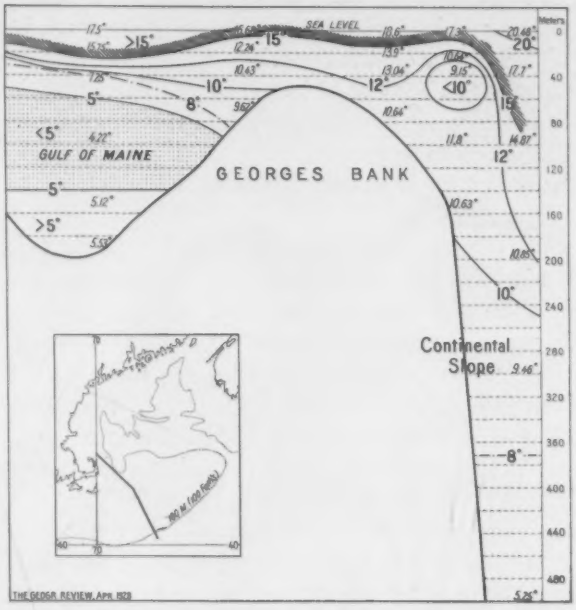


FIG. 2—Profile of temperature, running from a point off northern Cape Cod southeastward across the Gulf of Maine, Georges Bank, and the Continental Slope, for July 19–21, 1914.

has no counterpart in northern European waters. The nature of the boundary which holds apart these warm and cold waters—for a boundary, even if invisible, there must be—is a problem of great general interest.

In valuing the geographic significance of the temperatures of the Gulf of Maine, we must bear in mind its situation to leeward of the continent. Disturbances of the atmosphere, cyclonic and anticyclonic alike, move from the land out over the sea here; the reverse is the rule in Europe where land draws from sea. *A priori* then we might expect any partially enclosed basin at a moderately high latitude off the American coast to reflect the rigorous continental climate to the west of it. It is a rapid absorption of heat from spring to summer from solar warming, not a general overflow of the Gulf Stream from offshore, that we find reflected in the high summer temperature of the surface of the western part of the Gulf of Maine (Figs. 2 and 3).

Though a seeming paradox, it is equally this rapid heating of the surface by the sun that causes the continuance of low temperatures in the deep strata of the Gulf throughout the summer. Sea water is so comparatively opaque to solar radiation, of the wave lengths that carry most of the sun's energy, that the direct effect of the latter is expended close to the surface. As the surface warms, with little change in the deeper strata, the water column tends to become increasingly stable vertically. Unless this process be effectively combatted by strong tidal stirring, the underlying water becomes blanketed against thermal influences from above; the cold of the preceding winter is preserved into autumn; and summer temperatures as low as 4°–5° at a depth of 150 meters, or even at more moderate depths, are found in general over the western side of the Gulf of Maine.

The efficacy of thermal insulation of this sort depends chiefly on the local activity with which the tides stir the water. Where these run strong over irregular bottom or among islands, with active upwellings and overturnings that bring cold water constantly up from below and carry warmer surface water down, the solar heat is more evenly distributed. In such places the surface continues cooler through the summer, but the underlying strata warm more rapidly than elsewhere in the Gulf. The most notable local example of this is in the Bay of Fundy region in general, and in Passamaquoddy Bay in particular, where a cold surface in summer (10°–12°), long taken as evidence of an Arctic current, is now known[2] to reflect tidal churning so active that the sun's heat is spread through the whole upper 50 meters of water, instead of being absorbed by the upper 10–20 meters. Consequently, the water down to this depth is kept practically of that same temperature, even at the warmest season, when the bottom

[2] By observations by the Biological Board of Canada.

is warmer there than in Massachusetts Bay, though the surface is 8° or 9° colder. As a result of these local variations animals of subarctic affinity find a more favorable environment—i. e. lower temperature—in the deep water off Massachusetts Bay, and especially in certain partially enclosed sinks there, than anywhere in the opposite side of the Gulf. On the other hand, the considerable category of boreal animals confined to temperatures cooler than 12° or so must keep to deep water in the western side of the Gulf during the summer months; but in the Bay of Fundy they can live right up to tide line. This is another reason why the northeastern part of the Gulf has sometimes been loosely described as "arctic" in character.

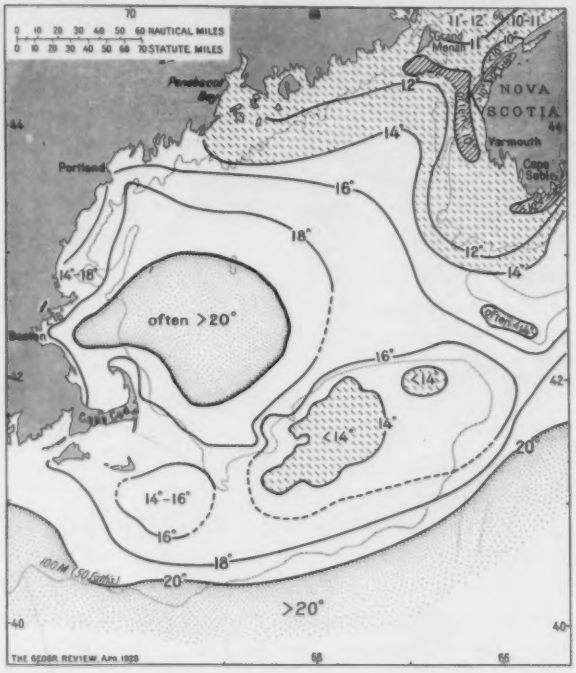


FIG. 3—Normal temperature at the surface of the Gulf of Maine for the last half of August, based on a combination of the available data.

The surface is also kept cold, by tidal stirring, along western Nova Scotia. Other areas of cool surface, similarly caused, and outlined on the chart (Fig. 3), are on the shallows of Georges Bank and on Nantucket Shoals, where the whole column is practically homogeneous surface to bottom, at summer temperatures varying locally from 12° to 14°. And the fact that the difference in mean summer temperature between Nantucket Shoals on the one hand and Passamaquoddy Bay on the other is no greater than their difference of 3½ degrees of latitude would call for is one of the many links in the chain of evidence that "arctic" is wholly a misnomer when applied to the cool surface of the northeastern part of the Gulf of Maine in general or of the Bay of Fundy in particular.

In summer, local upwellings of cool water often chill the surface close along the western coast of the Gulf when the wind blows offshore, a fact with which every bather is familiar. By this means the surface in Massachusetts Bay is usually kept some two degrees cooler

(less than 18°) in the coast strip between Boston and Cape Ann, than it is offshore (more than 18°). On the Nova Scotian side, however, whatever water may be brought up by such upwellings has about the same temperature as that which it replaces; and so is not made evident by its temperature.

The combined effect of these vertical movements of the water, balanced against local solar heating, is that the surface warms to the highest temperature over the deep basin in the offing of Massachusetts Bay (18°–20°), with a general west-east gradation to 10°–12° in the opposite side of the Gulf, as outlined on the chart (Fig. 3).

In most summers (not, however, in all) the Gulf is coldest in the mid-depths, at 100–150 meters (4°–5°), and is some two degrees warmer on the bottom of the basin at 175 meters and deeper. In this case it is clear enough that a cold layer of this sort reflects nothing more than the depth to which the previous winter's chilling penetrated, just as does a similar vertical distribution of temperature in the Baltic or the Black Sea. And the presence of a mass of warmer water underlying it, not only comparatively uniform in temperature but so saline as to be high in specific gravity, is direct evidence of an indraft over the bottom from offshore. This indraft must enter via the deep Eastern Channel, this being the only source from which the supply of water of this particular character could be maintained against its constant consumption by the various mixings of the water in the inner parts of the Gulf.

The surface of the Gulf, as a whole, is at its warmest in August. After the first of September the surface of the western side cools: first, by simply mixing with the colder water below as the absorption of solar heat decreases; next, through an actual loss of heat by radiation into the cooler overlying air. But as it is not until a month or more later that these changes affect the cooler surface of the eastern side, the regional differences in surface temperature decrease, until, by mid-autumn, the whole surface of the Gulf is in most years nearly uniform at 9.5°–10.5°, varying only a degree or two one way or the other from place to place. In 1915, a typical year, this state was attained between the first and middle of October. As the surface cools, vertical stability decreases, allowing tides, wave action, etc. more and more freely to bring up water from below to radiate out its heat to the air. At the same time and by the same process of mixture the mid-strata are warmed, so that the 40-meter level, off Massachusetts, is not at its warmest until October; the 70-meter level not until November, the 100-meter level not until early in December (Fig. 4). Thus the notable thermal stratification, characteristic of most parts of the basin of the open Gulf in summer, gradually gives place to a close approach to vertical homogeneity by the end of autumn at an average value close to 8°. For the upper

100 meters winter chilling is so rapid from that date onward that by the middle of February the upper 40 meters around the whole margin of the Gulf has chilled below 2° (Fig. 5): fractionally below 0° in Cape Cod Bay, where more or less ice alternately freezes and melts, and locally in the bays along the coast of Maine and of the Bay of Fundy.

Wherever winter chilling of the sea follows cold winds blowing out from the land, the water is coldest next the land. The Gulf of Maine is no exception; its surface temperature rising offshore to 3°–4°

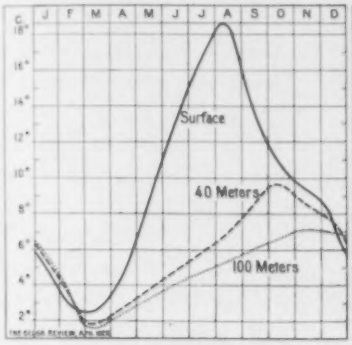


FIG. 4

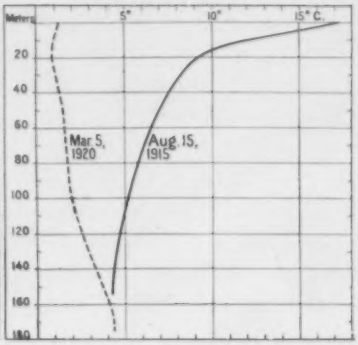


FIG. 5

FIG. 4—Normal seasonal progression of temperature at the mouth of Massachusetts Bay, based on a combination of the records from the several years of record.

FIG. 5—Temperature in the trough off the Isles of Shoals August 15, 1915 (solid curve), and March 5, 1920 (broken curve).

over the southern half of the basin, 3°–5° on Georges Bank, at the coldest season (February). Furthermore, the water is then coldest at the surface (Fig. 4), not warmest as it is in summer. Though the loss of heat is so rapid from the surface, the resultant cooling penetrates down only to a depth of about 100–150 meters during each winter. Deeper than this the temperature of the Gulf varies only a degree or two either way, from 5° to 6°, throughout the year or from year to year. Thus animals dwelling on bottom must be prepared to resist a seasonal variation of more than 16° in temperature if near tide mark; and if not able to survive temperatures close to the freezing point of fresh water, or even lower, they there run the risk of widespread destruction, such as sometimes befalls cunners and other fishes if overtaken in some shoal harbor by a sudden freeze. By swimming down a few fathoms deeper, as many fishes do, they can escape this risk.

In the Gulf of Maine, as in any lake or pond, winter chilling gives place to vernal warming from the date when the mean temperature of the air rises above that of the water. In the western and northern parts of the Gulf as a whole, this happens, in average years, about the

end of February. And in this general subdivision of the area the process leads directly to the summer state of high stability and of notable thermal stratification just pictured. In the eastern side, however, it is annually interrupted and may even be temporarily reversed by an inrush of icy water past Cape Sable from the eastward. This event falls earlier in some years than in others, our experience suggesting late March to late April as covering the period within which it is at its maximum in normal years. At this time water from this eastern source may chill the surface of the Gulf to 0° as far westward as longitude 67° 30′; such was, in fact, the case in 1919. But in all the years of record this drift has involved solely the upper stratum, shoaler than about 100 meters; and it has appreciably chilled the temperature of the Gulf for only a brief period, apparently synchronizing with the melting of ice far to the eastward.

When the flow from the east past Cape Sable diminishes, the icy water so brought to the Gulf is so soon thoroughly incorporated with the warmer waters it meets there that in most years the regional disturbance of temperature it at first effects is entirely obscured by June. After that month whatever surface water enters the eastern side of the Gulf from the offing of Cape Sable acts as a warming, not as a chilling agent, being 1–3° warmer than that with which it mixes to the westward of the Cape.

The most interesting question regarding this contribution to the Gulf from the east and northeast is, to what extent is its low temperature reponsible for the boreal character of the latter? Would the Gulf be considerably warmer without it? We cannot escape the conclusion that with the cold water flooding past Cape Sable every spring in considerable volume, the Gulf of Maine into which it enters must be cooler than it would if this supply were dammed off. But if this Nova Scotian contribution did cool the surface more than a degree or two below the value that would result from winter chilling alone, the mean temperature of the upper 40 meters would run considerably lower in the eastern side of the Gulf, into which it debouches, than in the western; whereas the regional difference in this respect is actually no wider than is called for by the difference in latitude. Nor does it appear, from a comparison with the deep Norwegian fiords and with the Black Sea, that the mean annual temperature even of the coldest stratum in the Gulf is lower than might be expected in an entirely enclosed body of water in the same geographical situation, being only 1°–3° lower than that of the overlying air.

Even, however, if this Nova Scotian current does not lower the temperatures of the Gulf of Maine, generally, more than a degree or two below the values which would prevail there were the Gulf closed to exotic waters, cold or warm, the comparatively high temperatures (6°–8°) of the current flowing into the bottom of the Gulf and of the

surface water entering in summer would hold the Gulf temperature considerably higher than is actually the case, were it not for the Nova Scotian current. And it is in combatting these sources of heat that the cold water from the east plays its chief thermal rôle in the Gulf of Maine complex.

Although it may now be accepted as definitely established that the waters of the Gulf of Maine, and of the coastal belt thence westward, can no longer be described as an "arctic" countercurrent (an explanation one may see in almost any one of the older textbooks), the nature of the icy water that undoubtedly does reach the Gulf by the route just mentioned deserves a word, because it is only within the past few years that its source has been definitely established.

Of old the responsibility was generally laid to the Labrador Current, of ill repute; perhaps without much analysis, and certainly without much actual evidence. For the Labrador Current to reach the Gulf of Maine would entail a general drift southwestward from the region of the Grand Banks, to cross the oceanic triangle separating the latter from the Scotian Banks. But actual explorations of that general area—begun with Schott's[3] study of the circulation of the Grand Banks region, continued by the Canadian Fisheries Expedition of 1914,[4] by the Biological Board of Canada, and by the surveys carried out yearly by the International Ice Patrol since 1914[5]—have reported no evidence of any such drift either in the temperature or salinity of the water or in the movements of the ice. So careful a record has been kept, by the Patrol, of the drifts of the bergs that come south with the Labrador Current and so thorough a survey of temperatures has been made at the season when the Arctic flow is at its maximum that any direct continuation of the latter toward Nova Scotia or the Gulf of Maine could hardly have escaped notice. It is also to the point that the cold current that skirts southward along Nova Scotia in spring and early summer is much less saline than the Labrador Current. It is separated, too, from the latter by much higher salinities (as well as temperatures) over the intervening deep.

Without delving further into the mass of evidence available elsewhere, it is established that the Labrador Current is hardly recognizable as a definite ocean stream more than a few miles south or west of the tail of the Grand Banks. On this, observers who have studied the Grand Banks region at first hand are unanimous. Certainly this current does not reach the coasts of Nova Scotia or of New England

[3] Gerhard Schott: Die Gewässer der Bank von Neufoundland und ihrer weitern Umgebung, *Petermanns Mitt.*, Vol. 43, 1897, pp. 201–212.

[4] Paul Bjerkan: Results of the Hydrographical Observations Made by Dr. Johan Hjort in the Canadian Atlantic Waters during the year 1915, Canadian Fisheries Expedition 1914–15 (1919), pp. 349–403, Dept. of the Naval Service, Ottawa.

W. J. Sandström: The Hydrodynamics of Canadian Atlantic Waters, *ibid.*, pp. 221–343.

[5] See the annual reports of the International Ice Observation and Ice Patrol Service, *U. S. Coast Guard Bulls.*

as a regular event, except indirectly via the Gulf of St. Lawrence or via the slope water and robbed en route of its thermal characteristics.

To some extent the cold of the drift that reaches the Gulf of Maine past Nova Scotia and Cape Sable mirrors the generally low vernal temperatures of the discharge from the Gulf of St. Lawrence around

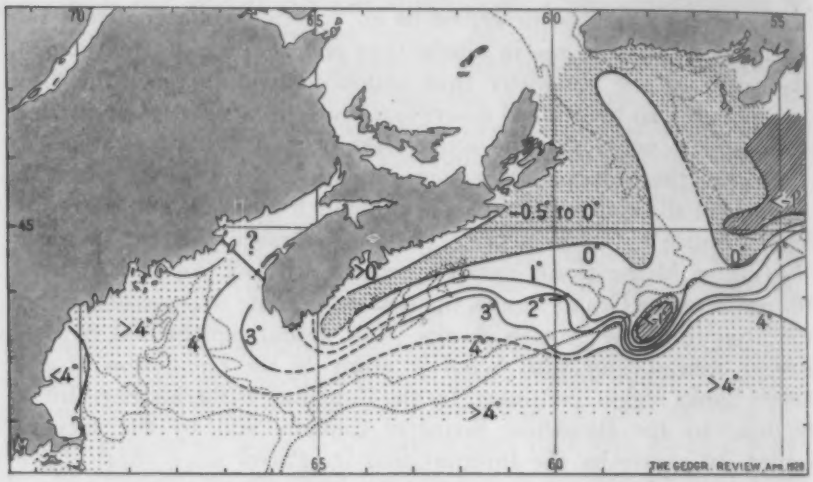


FIG. 6—Distribution of the coldest water in the upper 300 meters irrespective of depth, in May, 1915, based on data gathered by the Canadian Fisheries Expedition and by the *Grampus*.

Cape Breton—a current long known either as the "Cape Breton" or as the "Cabot" which in its flow reflects the enormous volumes of fresh water draining into that Gulf. But it is the melting of the ice which this current brings out of the latter in spring that is more directly responsible, for in its dispersal and disintegration this annually develops an icy pool in the region of Misaine and Banquereau Banks. From this, in turn, the combined records of the Canadian Fisheries Expedition, of the Ice Patrol, and of our own cruises show a tongue-like extension to the west, nearly to Cape Sable in the spring of 1915 (Fig. 6). And much evidence to this same effect has subsequently been accumulated, especially from the many series of drift bottles put out by the Biological Board of Canada.

A question of considerable interest to the biologist as well as to the oceanographer is how far to the westward the thermal effect of this cold Nova Scotian drift can be followed. This cannot yet be answered, categorically. But to it, directly or indirectly, is almost certainly due the low temperatures of the cold bands that have often been recorded just outside the edge of the continent in the offing of Nantucket. One such was traced along Georges Bank from the northeast to southwest in July, 1914. Phenomena of this sort have

been reported often enough to show that a movement of cold water takes place annually, in this direction, at least to longitude 69°, during the late spring or first days of summer. In summers when this drift is greatest in volume, or lowest in temperature, it may even maintain temperatures as low as 5° along the slope of Georges Bank at about the 100-meter level into July, as was the case in 1916. This, however, is shown by our experience in other years to have been unusual.

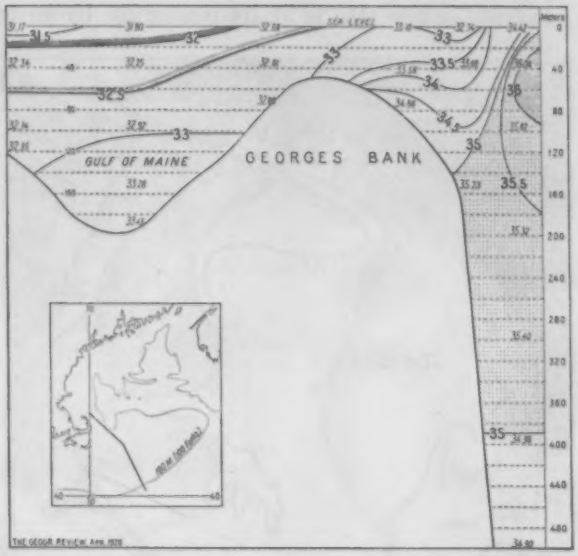


FIG. 7—Profile of salinity, running from a point off northern Cape Cod southeastward across the basin of the Gulf of Maine, Georges Bank, and the Continental Shelf, for July 19–21, 1914.

THE SALINITY OF THE GULF OF MAINE

During the last quarter century the view, once prevalent, that small variations in the total saltness of the sea water governed many vital phenomena in the sea has given place to appreciation that more significant in marine ecology are the variations in individual solutes, so dilute that their widest fluctuations make only very minor differences in the total salinity. To the physical oceanographer, however, the degree of salinity of the water is of the greatest interest, because of the light it throws on the sources of the waters concerned and because it is one of the two factors that determine the specific gravity of the water and consequently govern its dynamic circulation.

The Gulf of Maine, according to our many determinations, falls among the less saline of enclosed seas. It is much less saline than the North Sea, more so than the Baltic, but does not much differ from the Skagerrak which connects these two. On our own side of the North Atlantic it finds a parallel in salinity in the Gulf of St. Lawrence, whose waters are about as saline as those of the Gulf of Maine in the deep strata but slightly less so at the surface.

Taking one season with another, the surface of the Gulf of Maine, out to its offshore rim, averages about 32–32.5 per mille in salinity; the 100-meter level, typical of the mid-depths, 32.8–33 per mille;

the bottom, at 175 meters and deeper, 33.7–35 per mille. These values fall far below those of the Gulf Stream off the mouth of the Gulf of Maine; and the contrast is as abrupt in salinity along the edge of the continent (Fig. 7) as it is in temperature (Fig. 2).

Perhaps the most interesting aspect of the salinity of the Gulf is the wide regional variation in its inner parts. The recorded range in spring, when this is at its maximum (from less than 28 per mille to slightly more than 35 per mille) covers a range wider than that of the whole Atlantic basin outside the 1000-meter contour but closely corresponds to that of the North Sea and Skagerrak combined. As might be expected, the Gulf is invariably least saline around its periphery, where it is affected by its tributary rivers. However, we did not find it saltest along its offshore rim, as the close proximity of the Gulf Stream only 20–40 miles away led us to expect, but along a rather definite tongue, penetrating inward from the edge of the continent through the deep channel between Browns and Georges Banks and so northward toward the offing of the Bay of Fundy, there to swing westward parallel to the coast about as far as the longitude of Penobscot Bay. This distribution has appeared repeatedly on the charts of salinity for the mid-levels (Fig. 8); less clearly at the surface where it is obscured by the active stirring of the water.

FIG. 8—Salinity at a depth of 40 meters, July–August, 1914.

A wide seasonal variation is to be expected in the salinity of the uppermost stratum in northern seas, the basins of whose tributary streams are largely frozen and snow-covered in winter, with the streams in freshet when the snow melts and the ice goes out of stream and lake. This is illustrated in the Gulf of Maine by a sudden freshening of the surface around the margin in spring (Fig. 9) followed by a

progressive salting as the inrush of river water is gradually incorporated by the various circulatory movements already mentioned.

The maximum seasonal range of salinity so far recorded for any one station in the Gulf is in the Bay of Fundy, from a minimum surface value of about 28 per mille in May to a maximum surface salinity of about 32.7 per mille at the end of winter. This, with maximum of slightly more than 32 per mille and minimum of 28.3 per mille at the surface off the Merrimac River, suggests a seasonal variation of at least 4 per mille as usual for the surface along such sectors of the coast line as are most affected by land water. In the central parts of the Gulf, however, the maximum seasonal range yet recorded has been only from about 31.6 to about 33 per mille; i. e. less than half as much as next the land. And even where vernal freshening is most pronounced it is chiefly restricted to the upper 40 meters, the widest seasonal variation so far recorded at a depth of 100 meters being only about 1.2, while in the trough of the basin, deeper than 175 meters, the salinity continues virtually constant throughout the year and from year to year.

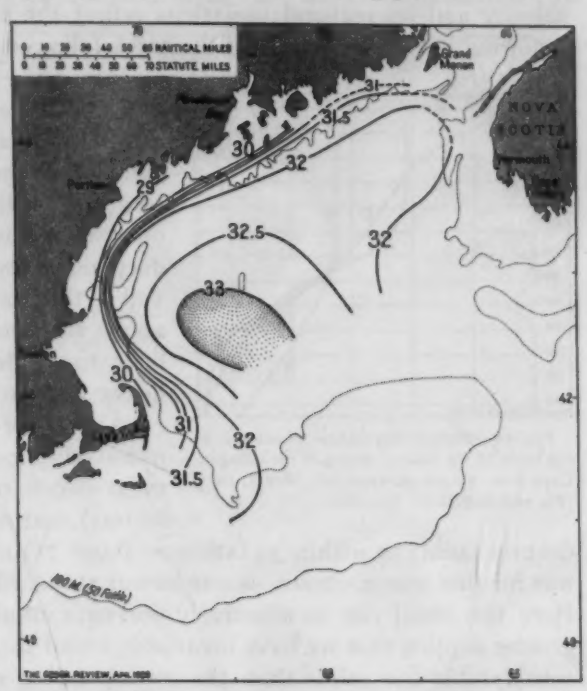


FIG. 9—Salinity at the surface for the first half of May, from the data for 1915 and 1920 combined.

Not less characteristic is the fact that throughout the spring and summer a very considerable vertical range of salinity prevails over most of the area of the Gulf, with the surface freshest and the bottom the most saline. The only exception is that where the water is most thoroughly churned by the tides, as it is in the region of Passamaquoddy Bay, the column is kept nearly homogeneous in salinity, from surface to bottom, just as it is in temperature. This vertical range rules widest in spring and summer, when the surface is least saline; narrowest at the end of winter, when the upper 40 meters is as nearly homogeneous in salinity as in temperature, though even

at that season the deeper strata show the salinity increasing with depth. Typical salinity gradients for the basin of the Gulf, winter and summer, are reproduced in Figure 10.

The events in the salinity cycle mentioned so far are bound up with fluctuations in the amount of land water entering the Gulf, either locally from its tributary streams or as a constituent of the Nova Scotian drift. In the deeps of the Gulf, however, the precise salinity and its regional variations reflect the varying pulses in the inflowing bottom current and the track followed by the latter.

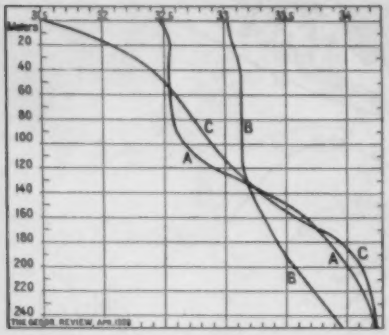


FIG. 10—Vertical distribution of salinity in the basin of the Gulf of Maine in the offing of Cape Ann, March 24, 1920 (A); May 5, 1915 (B); and August 22, 1914 (C).

Along the floor of the Y-shaped trough, in depths of 175 meters and more, this supply is sufficiently constant to hold the salinity close to 34 per mille year in and year out. But in isolated bowls equally deep much lower salinities may prevail if the rim rises high enough above the general level of the sea floor to hinder overflows by the heavy bottom water.

A bowl of this type some 15 miles off Gloucester, with maximum depth of 99 fathoms (181 meters) and a rim rising (at its deepest point) to within 39 fathoms (about 71) meters of the surface, was for this reason chosen as one of our standard observing stations. Here the shoal rim so effectively prevents interchange of water, at greater depths, that we have invariably found the bottom of the bowl considerably less saline than the corresponding stratum of the open trough of the Gulf near by (the differential has ranged from 0.4 per mille to 1 per mille) and vertically homogeneous, instead of showing the salting with increasing depth that is generally characteristic of the bottom water of the Gulf.

Lower rims less effectively divert the inflowing bottom drift from the Bay of Fundy (salinity at 175 meters close to 33 per mille within, 34 per mille outside) and from the deep trough enclosed between Jeffreys Ledge and the mainland.

THE CIRCULATION OF THE GULF OF MAINE

As our outlook broadens on the forces that set currents in the sea in motion, it becomes increasingly probable that its every part is the seat of a dominant movement of the water in one direction or another, enduring over periods longer than that of the tidal oscillation. Where tides run strong, these may prevent recognition of the underly-

ing circulation. Until its systematic exploration was undertaken, this was true of the Gulf of Maine. Even at an earlier date, however, a dominant set to the southeast, past Cape Cod and the region of Nantucket Shoals, had been recorded at numerous localities by the U. S. Coast and Geodetic Survey (Fig. 11). And Mavor's[6] recent analysis of current measurements taken in the eastern side of the Gulf by the Tidal Survey of Canada, under the direction of Dr. W. B. Dawson, has shown a still more pronounced non-tidal component, setting northerly along the Nova Scotian shore, into the southern side of the Bay of Fundy and out of its northern side.

FIG. 11—Direction of the dominant current at stations of the U. S. Coast and Geodetic Survey, of the U. S. Bureau of Fisheries, and of the Tidal Survey of Canada. The arrows swim with the current.

These together point to an anticlockwise type of circulation around the coast line of the Gulf of Maine. And, as our observations on the temperature, salinity, and plankton of the Gulf have accumulated, it has become increasingly apparent that the Gulf as a whole is in fact dominated by a rather definite movement of this sort. The existence and prevalence of this "Gulf of Maine" eddy, is most clearly revealed by the regional variations in salinity. The open ocean off its mouth is its only possible source for water of very high salinity, while low salinity as clearly reveals the lines of dispersal of river water. Consequently the saline entrant tongue in the eastern side, just described (Fig. 8), is direct evidence of a current from offshore inward around the eastern side of the basin of the Gulf, with the successive isohalines outlining its continuation westward and southwestward around the northern side. On the other hand, the evident tendency of the freshest water—especially at the season when coastwise

[6] J. W. Mavor: The Circulation of Water in the Bay of Fundy, Part I: Introduction and Drift Bottle Experiments, *Contribs. to Canadian Biol.*, Vol. 1 (N. S.), 1922, pp. 103–124.

salinity is lowest—is not to fan out off the mouths of the great rivers, as would happen were there no longshore tendency in the one direction or in the other, but to hug the land (Fig. 9), positive evidence of a general movement parallel with the coast. This is one of the most interesting phenomena in the hydrographic cycle of the Gulf.

In the mid levels, where the Gulf is entirely enclosed except for the narrow channels that pierce its southern rim, the regional distribution of salinity—highest in the eastern side—equally points to an anticlockwise movement of the water (Fig. 8).

FIG. 12—Locality records for certain of the most typical oceanic immigrants of tropical origin, short-lived in the lower temperatures of the Gulf of Maine, including Salpae, Euphausiids, Copepods, Siphonophores, Sargassum. (For more detailed chart see *Bull. Bur. of Fisheries*, Vol. 40, Part II, p. 53, Fig. 31.)

Salinity is also a good index to the lines of dispersal of the Nova Scotian current in the Gulf, by the freshening of the surface effected by it. It would equally disclose any overflows by the Gulf Stream, should such occur.

Dislocation of the isotherms likewise follows the westward flood of icy water past Cape Sable in spring and therefore discloses it when the temperatures are charted. Otherwise temperature is not so trustworthy an index as is salinity to the dominant movement within the Gulf, because of the rapidity with which the water may warm by solar heating or may cool by winter chilling, etc. Hence this phase may here be passed over with the remark that many more or less disconnected bits of thermal evidence combine to corroborate the evidence of salinity and to prove the prevalence of the Gulf of Maine eddy.

The geographic distribution of the various planktonic immigrants which, from time to time, visit the Gulf of Maine, affords equally instructive evidence of their lines of drift and for two reasons. First, they come from diametrically opposed sources—tropicals from the

Gulf Stream, arctics from the icy Nova Scotian current of spring. Second, certain of them are so short-lived within the Gulf—the one category finding its waters too cold, the other too warm—that their occurrence at any station is sure evidence of a movement of water thither, shortly previous, from outside. On plotting the recorded capture of these ephemeral visitors, tropics (Fig. 12) and arctics together, they all have proved to be concentrated in a rather definite zone, extending inward from the Eastern Channel and Browns Bank, around the northern and western margins of the Gulf, to the offing of Massachusetts Bay. This distribution closely parallels that of the saltest water and is explicable only on the same basis, as due to an anticlockwise eddying drift. The scarcity of tropicals over Georges Bank and in the central part of the basin, just where they would naturally be most frequent if they drifted in directly from the south, is especially suggestive.

The courses of some 1500 drift bottles put out in the western side of the Gulf since 1922, with many others launched in the eastern part and in the Bay of Fundy by the Biological Board of Canada, are again reconcilable with one another, and with the distribution of salinity and of the plankton, only on the assumption that the waters of the Gulf eddy anticlockwise (Figs. 13 and 14).

With enough river water emptying into the Gulf to raise its surface by about ½ a fathom yearly (local rainfall more than balances evaporation) and with indrafts into its eastern side, both deep and on the surface, obviously the Gulf discharges somewhere and in large volume. Salinities and the drifts of bottles locate this discharge as chiefly out of its western side, past Cape Cod and Nantucket Shoals and partly clockwise around the eastern end of Georges Bank, so joining the more widespread set that trends southwestward along the edge of the continent.

Causes of the Dominant Circulation of the Gulf

Three possible motive forces at once spring to mind in explanation of this dominance of the basin of the Gulf by a great anticlockwise eddy: the hydrostatic forces set in operation by regional differences in the density of the water; the winds; and, as newly suggested by Dr. A. G. Huntsman,[7] the tidal oscillations as deflected by the effect of the earth's rotation.

Within recent years the application of Bjerknes' hydrodynamic theory to ocean currents has been so simplified, especially by Ekman, Helland-Hansen, Sandström, Hesselberg and Sverdrup, and Smith, that no oceanographer need longer dread the mathematical processes

[7] A. G. Huntsman: The Importance of Tidal and Other Oscillations in Oceanic Circulation, *Trans. Royal Soc. of Canada*, Ser. 3, Vol. 17, 1923, Section V, pp. 15–30.

necessary for dynamic study of the seas with which he is concerned. The physical laws involved are indeed of the simplest, embodied in the old adage "water runs downhill." Unfortunately, however, deduction of the movement of the water from the calculated dynamic gradients gives relative results only, not absolute. The correctness of the deduced current, relative to the bottom (which is what really concerns us), depends on the assumption that somewhere in the picture there is motionless water to start from. And this entails the second assumption that a correct choice has been made of the station or stratum assumed stationary or nearly so; neither of which assumptions is capable of mathematical proof.

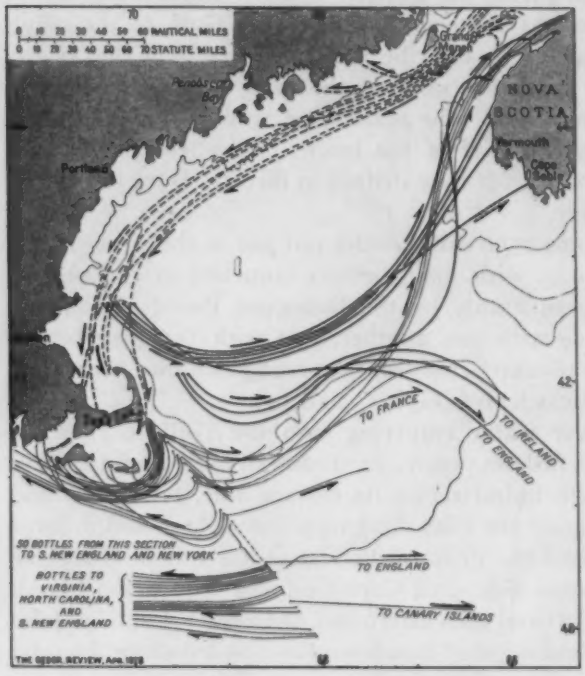


FIG. 13—Assumed drifts of bottles put out in the Bay of Fundy in the summer of 1919 by the Biological Survey of Canada (broken curves, after Mavor); to the southward of Cape Cod in July, 1922 (solid curves); in the offing of northern Cape Cod and off Cape Ann in August, 1923 (solid curves).

The method of attack adopted for the Gulf of Maine has been that of the dynamic contour chart, chosen as the simplest application of Bjerknes' theorems and as on the whole the most instructive for areas where a network of observing stations allows horizontal projection of the dynamic gradients. Projections of this sort can also be constructed for any desired pressure depth below the surface—an added advantage. The procedure employed in this method, widely used of late, has recently been described in full detail by Smith[8] as applied to deep oceans. When extended to shoal seas, varying in depth from station to station, as Jacobsen and Jensen emphasize,[9] complications ensue

[8] Edward H. Smith: A Practical Method for Determining Ocean Currents, *U. S. Coast Guard Bull. No. 14*, 1926.

[9] J. P. Jacobsen and A. J. C. Jensen: Examination of Hydrographical Measurements from the Research Vessels "Explorer" and "Dana" during the Summer of 1924, *Rapports et Procès-Verbaux des Réunions, Conseil Perman. Internatl. pour l'Expl. de la Mer*, Vol. 39, 1926, pp. 31–84: reference on p. 40.

Trans. Royal Soc. of Canada, Ser. 3, Vol. 17, 1923, Section V, pp. 15–26.

due to the necessity for taking into account the whole mass of water between every pair of stations and not merely the depth column included at the shoaler of the two. In the present state of our knowledge, this allowance entails an empiric correction which admittedly can give only an approximation to the truth. Consequently the opportunity offered in the Gulf of Maine to correlate the prevailing dynamic state of the water with a well marked and persistent type of dominant circulation, fully demonstrated by other lines of evidence, has been most welcome. Our procedure in this case, backward (if you will) from effect to cause, reverses that of several recent studies and purposely so.

FIG. 14—Assumed drifts of bottles set out in the offing of Cape Ann in April, 1926; in the offing of Cape Elizabeth and off Mt. Desert Island in August, 1923.

For reasons too technical to discuss here, the gradients shown on a dynamic contour chart simulate the actual slope of the surface more or less closely, according to the correctness of the underlying assumptions just stated and of the empiric allowance made for differences in depth between adjacent stations.

Such a chart resembles an ordinary weather map in general appearance and is to be interpreted similarly. That is, the water tends dynamically to flow down from the parts of the picture where the surface stands highest, to the depressions where the surface is lowest. But the deflective effect of the earth's rotation—to the right in the northern hemisphere—actually brings the drift so nearly parallel to the dynamic contour lines that these last may be taken as representing the stream lines wherever the contour of the bottom allows—and this is a very important proviso—the current having the highest surface (lightest water) on its right hand in the northern hemisphere, on its left hand in the southern.

The dynamic contour charts for the surface of the Gulf of Maine have proved fundamentally similar from season to season, with the surface invariably standing highest alongshore, lowest somewhere over the basin (the precise locality varying from month to month) and outside the edge of the continent. Some such distribution was, of course, to be expected from the large amount of fresh (i. e. light) water emptying into the Gulf around its coast line, with the surface highest close to the greatest inflowing of fresh water, just as rules in the North Sea.

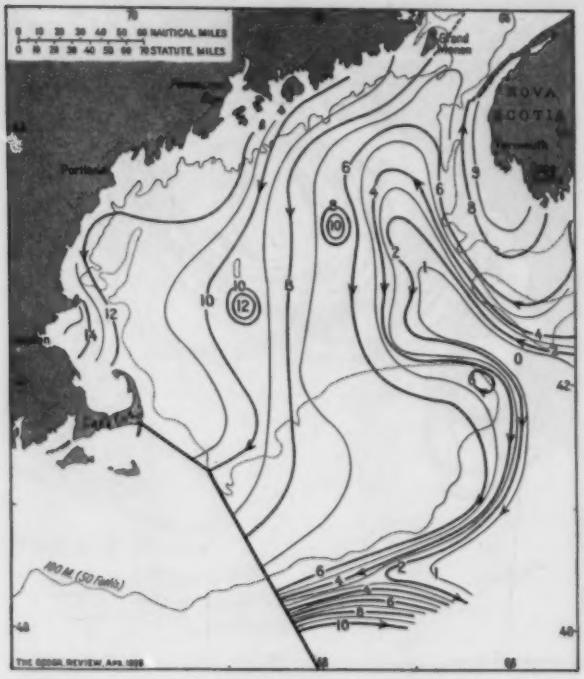


FIG. 15—Dynamic contour of the surface of the Gulf of Maine, February–March, 1920, referred to the depression in the eastern channel as base. Contours in dynamic centimeters. From p. 937, *Bull. Bur. of Fisheries*, Vol. 40, Part II.

The seasonal changes in the state of the Gulf, in summary, have been as follows in the years of record. At the end of the winter the surface is lowest over and just within the Eastern Channel, rising steeply over the banks on either hand and radially in toward the coast line (Fig. 15). By April, as the margin of the Gulf is freshened (hence lightened) by the river freshets, the dynamic slope of the surface is steepened along the northern and western slopes, while the "low" spreads to include the whole eastern side of the basin. The gradient is still steeper in May, when the surface is lowest in the western side of the basin. In summer, as the land water is mixed into the Gulf of Maine and the regional differences that have been already discussed develop in the warming of the water, the surface slope flattens next the shore, while two depressions develop offshore, the one in the offing of Mt. Desert, the other over the Eastern Channel, with a steep rise along the eastern face of Georges Bank (Fig. 16).

During the autumn and winter progressive equalization of temperature and of salinity in the shoaler strata of the Gulf again trans-

form the dynamic contour of the Gulf to the more simple state characteristic of the early spring.

These contour charts make it evident that, on the whole, hydrostatics, as confined by the contour of the bottom, do actually tend to produce an anticlockwise movement of the surface water around the basin of the Gulf of the type recorded by the more direct lines of evidence just summarized. There is, in fact, no movement called for by the dynamic contours that is not also indicated by bottle drifts, by salinity, by temperature, or by the plankton.

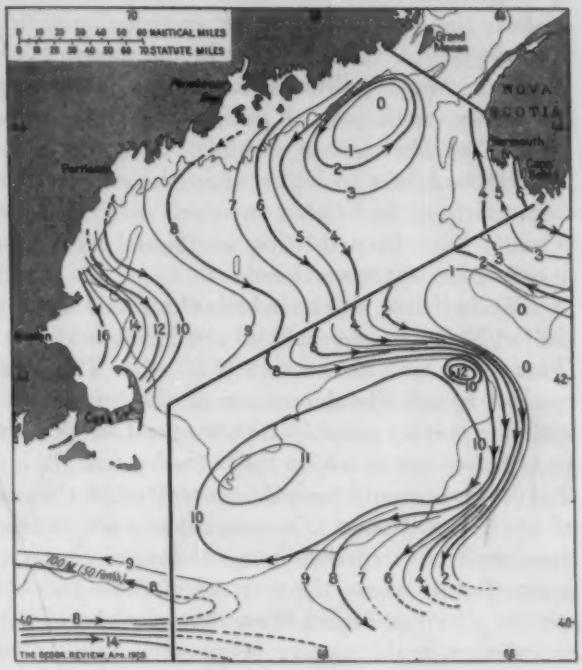


FIG. 16—Dynamic contour of the surface of the Gulf of Maine, July (north and west of the heavy dividing line) and August (south and west of the division), 1914. Contours for every dynamic centimeter from p. 936, *Bull. Bur. of Fisheries*, Vol. 40, Part II.

One other aspect of these dynamic charts demands space, because it is explanatory of important phenomena otherwise puzzling: namely the contours around the eastern and southern slopes of Georges Bank.

One of the most interesting facts in the Gulf of Maine complex is that the Gulf Stream, drifting close past its offshore slope, should so little affect the waters within the Gulf. On the opposite side of the North Atlantic—in the Bay of Biscay for example, and northward over the Norwegian Sea—northerly encroachments by the warm oceanic water are annual summer events of great importance in biologic economy. Topographically, at least, the Gulf of Maine lies equally wide open to overflows from the Gulf Stream; and the strong southerly winds, frequent in summer, would favor such. However, the boreal character of the fish fauna and of the bottom dwellers generally, not only within the Gulf but over its outer rim even out nearly to the edge of the continent, proves that if such overflows do occur, they must be confined to a very superficial stratum. And fortunately so; for existence on Georges and Browns Banks and

on Nantucket Shoals would be impossible for cod, haddock, halibut, and other boreal fish were they sporadically subject to the sudden and extreme warming of the water which any voluminous flooding by the Gulf Stream would cause.

Actually no such event has come under our observation in any year or season, the nearest approach being early in September of the past summer, when Mr. C. Iselin found the bottom water 12° in temperature, the surface 21°, along the 100-meter contour on the offshore slope of Georges Bank, contrasting with 14–18° on the fishing grounds on the Bank. Later in the month "*Albatross II*" reported large amounts of gulfweed (*Sargassum*), with tropical fishes, scattered over the eastern part of the Bank. But, as the temperature there (13°–15° at the surface, about 9° at 40 meters, and about 8° at 70 meters) was then no higher than the expectation for the season, this tropic flotsam had either involved only the surface skim or it may actually have been drifting south and west at the time from some overflow far to the eastward.

The invisible barrier which shuts out the Gulf Stream from the Gulf of Maine is suggested on the dynamic charts for the warm season (Fig. 16) as well as the cold (Fig. 15). Thus the latter shows a well marked trough-like depression of the surface, paralleling the slope, with the surface notably higher over Georges Bank on the one hand and further out at sea on the other—a trough, in fact, of just the sort that has repeatedly been demonstrated in the corresponding location off the Grand Banks. Oceanographers are, indeed, learning to expect some such phenomenon along the line of contact between banks and ocean waters, where the mixture of these two constituents results in specific gravities higher than that of either. Wherever such a state prevails, as in the picture in question (Fig. 15) with dynamic slopes so steep, any transgression of the water across the trough in either direction is made impossible by the development of an easterly movement along its outer edge, and of a westerly movement along its inner edge, as the rotation of the earth directs to the right (and parallel with the contour lines) the draft of surface water that gravity tends to set in motion inward toward the trough from both sides. That the inner edge of the Gulf Stream thus receives easterly propulsion from hydrostatic forces acting locally, i. e. is strictly a gradient current at least at times and is by these same forces barred from the Gulf of Maine, is not the least interesting result of our work. The summer chart (Fig. 16) suggests this as applying also in the warm season, though here the picture is not so clear. Mr. C. Iselin is now engaged in a detailed study of this whole question, as it affects the Gulf Stream off the northeast coast of North America.

If this explanation be correct, the local hydrostatic forces are also the key to another riddle, namely the prevailing tendency for

warm oceanic water to wash the bottom along the continental slope, at the 100–200 meter level, as the well known "warm band," as far east as longitude 67°–68°, the precise boundary varying from season to season, but never, so far as known, to reach the Nova Scotian slope. In other words this may explain why the tilefish zone, with its equable bottom climate of 8°–12° the year round, is sharply bounded on the east.

To explain the temporary obliterations of the warm zone that are known to occur at long intervals with widespread mortality—witness the destruction of the tilefish in 1884—it is no longer needful to assume some overwhelming flood of arctic water from the north. A more likely explanation, and a simpler one, is that such events reflect some offshore shift in the location of the axis of the dynamic depression, allowing the cool discharges from the Gulf of Maine and the Banks water generally, in their drift toward the west, to spread farther out over the slope than usual.

Finally, the existence of such a dynamic trough along the zone of contact between coast and ocean waters provides propulsive power for the indraft into the bottom of the Gulf of Maine by which its estuarine character is maintained. The offshore origin of this inflowing bottom water is obvious. As obviously, however, it is not a direct indraft from the mid-depths of the ocean basin, being too little saline. Temperature (close to 8°) and salinity (34–35 per mille) as it creeps inward along the trough of the Eastern Channel between Georges and Browns Banks identify it as drawing at a corresponding depth from the cool wedge which intervenes between the edge of the continent and the inner edge of the Gulf Stream off the mouth of the Eastern Channel—the "cold wall" of the early oceanographers.

The origin of this comparatively cool water mass has been the subject of much speculation. An arctic source we have dismissed: certainly the "cold wall" off the deep channel of the Gulf of Maine and off Nova Scotia is not the direct and unadulterated southerly extension of any arctic current. Upwellings from the Atlantic abyss, did such events occur with frequency or regularity, would be another possible source for water of high salinity and of moderately low temperature, not only along the continental slope but for the basins on the American continental shelf as well. And upwellings of this sort have, in fact, been invoked in explanation, notably by Pettersson. Fortunately for our purpose the effect that any general updraft of this sort would exert on the physical character of the coastal water would be made as unmistakable by high surface salinity as it would in summer by low temperature, the neighboring abyss being about 34.9 per mille in salinity and not far from 4° in temperature. A vertical continuity, in temperature and in salinity, might also be expected between any updraft that might approach the surface

and its deep-lying source. Actually, however, our first cruise, in the summer of 1912, proved that at least the inner parts of the Gulf of Maine receive little if anything from this abyssal source, its coldest stratum (4°–5°) being much too fresh (33 per mille)—a conclusion subsequently corroborated for other times of the year. The profiles since run across the edge of the continent have shown the precise combination of temperature and salinity characteristic of the cool water abreast the Gulf to be incompatible with an abyssal source, as being considerably warmer (6°–7°) than the oceanic deeps (600 meters and deeper) where the salinity is so low; correspondingly less saline than the corresponding temperature zone offshore.

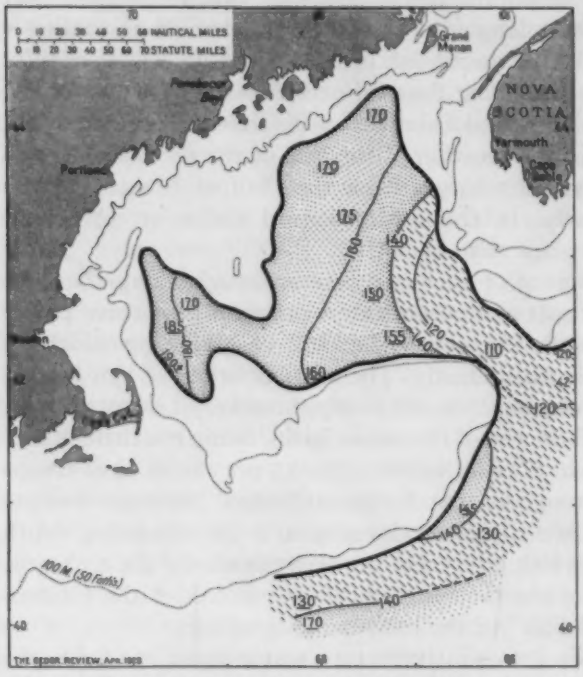


FIG. 17—Depth, below the surface of the stratum of 1.0275 specific gravity, at the temperature *in situ*, and corrected for compression, February–March, 1920.

Not only is this the rule generally along the seaward slope of the offshore banks, but even in the trough of the Eastern Channel, i. e. in the only deep entrance into the Gulf of Maine. In most cases, in fact, the coldest waters on the shelf have been separated from the equally low temperatures of the abyss by a somewhat warmer zone washing the bottom along the slope at intermediate depths (Fig. 2). Obviously, such a discontinuity in temperature argues against any prevailing movement of the water upward over the upper part of the slope. This conclusion does not mean that abyssal water may not well up over the deeper part of the continental slope. On the contrary, considerable evidence has accumulated to the effect that some such process is widespread below the 500–1000-meter level. But data so far gathered locate the upper limit of this updraft at a depth of at least 300 meters below the surface.

Actually the temperature and salinity of the sector of the "cold wall" that fronts the Eastern Channel mark it as the simple product

of the mixture ever taking place between the water of the Banks on the one hand, and that of the ocean basin on the other along the zone of their conflict; the one low, the other high in salinity and in temperature. "Slope water" is then an appropriate name for it. It is because the most saline bottom water of the Gulf has this "slope" origin, and is not oceanic, that members of the bathypelagic plankton of the Atlantic basin occur only as the rarest of stragglers within the Gulf: the whole category of the black fish—red prawn community, for example, and the deeply pigmented medusae of similar biologic status. The high specific gravity of this "slope water" is responsible for the dynamic trough just described as fronting the Gulf of Maine. The profiles that have been run out from the outer coast of Nova Scotia have shown similar phenomena at about the same location relative to the edge of the continent.

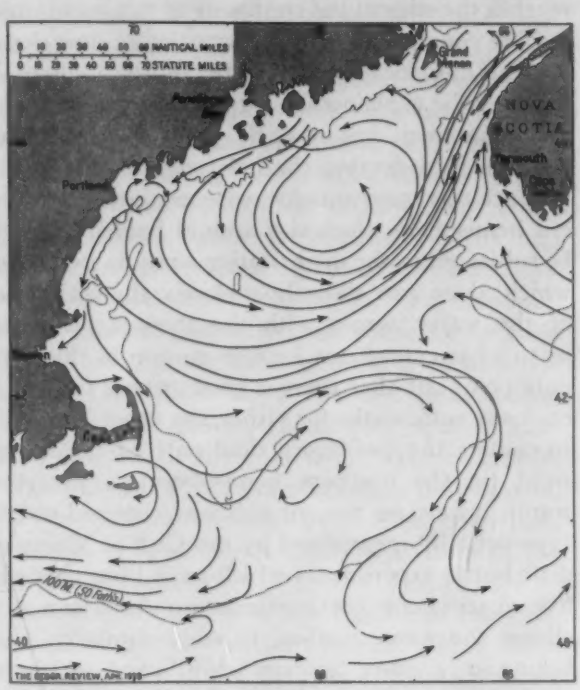


FIG. 18—General outline of the dominant circulation of the surface waters of the Gulf of Maine, in July and August. From p. 973, *Bull. Bur. of Fisheries*, Vol. 40, Part II.

Slope water is thus carried westward along the edge of the Nova Scotian shelf as a gradient current, just as it is along the southeastern face of Georges Bank (Figs. 15, 16). So long as this state persists, the submarine bight off the mouth of the Eastern Channel is kept supplied with water from the eastward, from the seaward slopes of Browns and La Have Banks; probably never from the westward. Forced against Browns Bank by the deflective force of the earth's rotation, the channel offers an open route for the slope water into the bottom of the basin of the Gulf of Maine, a route followed in pulses the secular succession of which is not yet clear. The surfaces of equal density dip steeply from the channel inward across the basin (Fig. 17); only by a constant renewal of water of high specific gravity at the offshore side could this unstable state be maintained

against the constant tendency of the force of gravity to reduce the surfaces of equal pressure to the horizontal.

Once it has penetrated the bottom of the Gulf, the slope water is consumed in the inner part of the basin, where vertical stirrings mix it with the overlying strata. Thus freshened by incorporation with much lower salinities, it is again discharged out of the Gulf near the surface, as a constituent of the ordinary Banks water; and when it reaches the edge of the continent in this way it again takes part, as the inshore constituent, in the formation of new slope water farther west.

The anticlockwise character of the Gulf of Maine eddy cannot, however, be explained as a gradient drift pure and simple because, as Dr. Huntsman has recently pointed out, the effect of the earth's rotation in deflecting the horizontal oscillations of the tides tends to produce this same anticlockwise movement within basins in the northern hemisphere, clockwise around banks. This hypothesis is still to be subjected to the quantitative analysis for any one particular region, which alone can show how closely the actual progressive movement of the water agrees with the theoretic expectation in its velocity or to what extent it is kept in motion in this way. Meantime, I can only point out that there is good ground for concluding that in basins enclosed sufficiently for either the coast line or for a submerged rim to confine the oscillatory tidal path of the water as deflected to the right (in the northern hemisphere), a progressive movement will result, inward on the one side and outward on the other, of just the type actually exemplified by the Gulf of Maine eddy. The extensive drift-bottle experiments which have been carried out during the past five years along the northeastern American seaboard have in fact shown the water tending to eddy similarly, anticlockwise, in other basins, e. g. the "Scotian eddy," and to circle banks and islands clockwise, just as this theory of deflected tidal oscillations demands.

Finally, the wind must be taken into account, as it affects the circulation of the waters of the Gulf of Maine. This is a complex problem, difficult of solution because of the impossibility of deriving, from any theoretic calculation, the track to which the contour of shore line and bottom will actually divert the current which any given wind would set in motion in the "free ocean" of the oceanographers.

The best indications of this resultant track are the currents which have actually been found to follow different winds at various lightships. Briefly, these show that, when not actually opposed by the coast line, wind currents near the land in our hemisphere are diverted by earth rotation on the average 20° to 25° to the right of the wind. Thus the prevailing south-southwest winds of summer help maintain the drift out from the western shore of the Gulf of Maine and eastward across the southern side of its basin toward Nova Scotia—

i. e. the southern side of the Gulf of Maine eddy. The wind is thus partly responsible for the accumulation of warm surface water in the offing of Massachusetts Bay in July and August. Any such wind drift across the southern side of the Gulf, striking the coast of Nova Scotia, naturally tends to strengthen the northerly movement across the wind-current track, otherwise kept in motion in that side of the Gulf. But the return movement westward around the northern shore of the Gulf is contrary to the wind.

Winds prevailing from the sector between southwest and north in winter and early spring tend, similarly, to strengthen the southerly drift along the western shores of the Gulf that results from the in-pouring of fresh water, with the consequent elevation of the surface. And northwest winds favor the discharge out of the western side of the Gulf. But, like the eastern side of the Gulf of Maine eddy, this latter is across the wind-drift track during the summer months; and the westerly movement of the slope water along the edge of the continent is directly opposed by the prevailing winds. Furthermore, though prevailing from the quarters just stated, the winds are variable over the Gulf of Maine at all seasons, seldom blowing in any one constant direction for more than a few days. On the whole, therefore, we may conclude that the general circulatory system that dominates the superficial stratum of the Gulf is not kept in motion by the winds, though the latter favor it more often than they oppose. And, if our theoretic concept of wind-driven currents be at all just, it is certain that the indraft of slope water into the bottom of the Gulf is entirely independent of the wind.

The dominant circulatory movements of the Gulf of Maine may thus be described as composed of three major systems. First, there is the anticlockwise eddying of the upper stratum around the basin of the Gulf, kept in motion by the local hydrostatic forces, plus the progressive motion resulting from the deflective effect of the earth's rotation as this acts on the tidal oscillations. Second, we have to do with the pumping of slope water inward along the floor of the Gulf from offshore, which is effected again hydrostatically by the balance maintained between the maintenance of a supply of such water off the Eastern Channel and its consumption in the inner parts of the Gulf. Third, there is the constant discharge from the Gulf near the surface, balancing this indraft and the indrafts at the surface from the offing of Cape Sable; balancing, too, the contribution of river water that the Gulf annually receives. To all of this the Gulf of St. Lawrence offers so close a parallel that this scheme is clearly typical for basins of this general topographic type, if they bear a similar relationship in temperature to the oceans they front.

The features of the Gulf so far mentioned—temperature, salinity, and dominant circulation in its broad outlines (not yet in detail)—

are now known, broadly speaking. With their elucidation the first objective of our physical exploration of its waters has been attained. The final goal, the explanation of the natural economy of its inhabitants in terms of their physical and chemical environment, lies, however, far ahead. This is to be sought not so much by the generalized surveys of a large area carried out so far as by more detailed study of the physical, and especially of the chemical, changes in the water from season to season at standard locations. How fertile such studies may be expected to prove is made evident by the very striking parallelisms between the abundance of vegetable plankton and the varying concentration in the sea water of such ultimate foodstuffs as phosphorus, nitrogen, and silica, such as have recently been demonstrated by the British naturalists at Plymouth[10] and by Raben at Kiel.[11]

Up to date, our only contribution of this sort, for the waters of the Gulf of Maine, has been a series of periodic determinations of the silica content of the water off Gloucester during the years 1920 and 1921, which showed a decided maximum in February–March (2.6–3 parts per million) followed by a notable impoverishment (to .4 part per million) in May, with a secondary maximum (1.4 parts per million) at the end of June, followed in turn by a second depletion in late summer and early August.

As described elsewhere[12] this corresponds in general with the usual seasonal schedule of diatoms in that general region, the active flowering of spring and the secondary flowering of September following the maxima for silica so closely that a causal connection is at least probable though not demonstrated.

---

[10] W. R. G. Atkins: The Phosphate Content of Fresh and Salt Waters in Its Relationship to the Growth of the Algal Plankton, *Journ. Marine Biol. Assn.*, Vol. 13, pp. 119–150, Plymouth, Engl., 1923–25; *idem:* Seasonal Changes in the Phosphate Content of Sea Water in Relation to the Growth of the Algal Plankton during 1923 and 1924, *ibid.*, pp. 700–720.

[11] E. Raben: Quantitative Bestimmung der im Meerwasser gelösten Kieselsäure, *Wiss. Meeresuntersuchungen, Komm. zur wiss. Untersuchung der deutschen Meere*, Vol. 8 (N. S.), pp. 99–101, pp. 279–287; Vol. 11, pp. 303–319; Vol. 16, pp. 207–229, Kiel and Leipzig, 1905, 1910, 1914.

[12] H. B. Bigelow: Plankton of the Offshore Waters of the Gulf of Maine, *Bull. U. S. Bur. of Fisheries*, Vol. 40, Part II, 1926, p. 476.

WHITE COAL IN ITALIAN INDUSTRY

W. O. Blanchard

University of Illinois

ITALY, until recent years, has been almost exclusively a nation of farmers, and even today over one-half of the population is directly dependent for its livelihood upon the exploitation of the soil. The past third of a century, however, has witnessed a remarkable industrial development. The world war, with its restriction upon imports and at the same time with its enormous demands for manufactures, greatly accelerated a movement which is making of northern Italy an industrial region of no insignificant proportions.

For the explanation of this rapid growth, one need not seek far. Considering its resources, Italy is one of the most densely populated countries of Europe. Ribbed with youthful mountains and having considerable areas deficient in rainfall, to support its population of over forty millions by agriculture alone is out of the question. Furthermore, population is increasing rapidly with an annual excess of births over deaths of some 400,000. Two solutions for the disposition of the surplus man power present themselves, emigration and industrialization. The former has long served as the major safety valve of overpopulation. In the absence of an extensive colonial empire there has been a huge annual exodus to the countries of the New World and to adjacent countries in the Old World. From 1910 to 1913 the average emigration was about 700,000 annually. The war and restrictive legislation, particularly in the United States—the most favored destination—reduced the numbers so that in the six years from 1921 to 1926 they have averaged slightly under 300,000. This situation goes far in helping to explain Italy's efforts in recent years to enlarge her colonial empire, to intensify her agriculture, and to expand her industrial activities.

Obstacles to Industrialization

The unique character of Italian industrialism lies in the formidable nature of the obstacles with which it is confronted. Italy has but scant supplies of the basic raw materials and still less of the fuels—two requirements the possession of at least one of which has been considered fundamental for a modern industrial nation. In fact, Italy is the least self-contained of all the great industrial nations of the world. Her industrial structure is supported instead upon

the two pillars of an abundant supply of comparatively cheap but efficient labor[1] and an unusually rich endowment of water power.

Italy's reserves of coal, lignite, and peat are estimated to total only 340 million tons; and of this amount almost 90 per cent is lig-

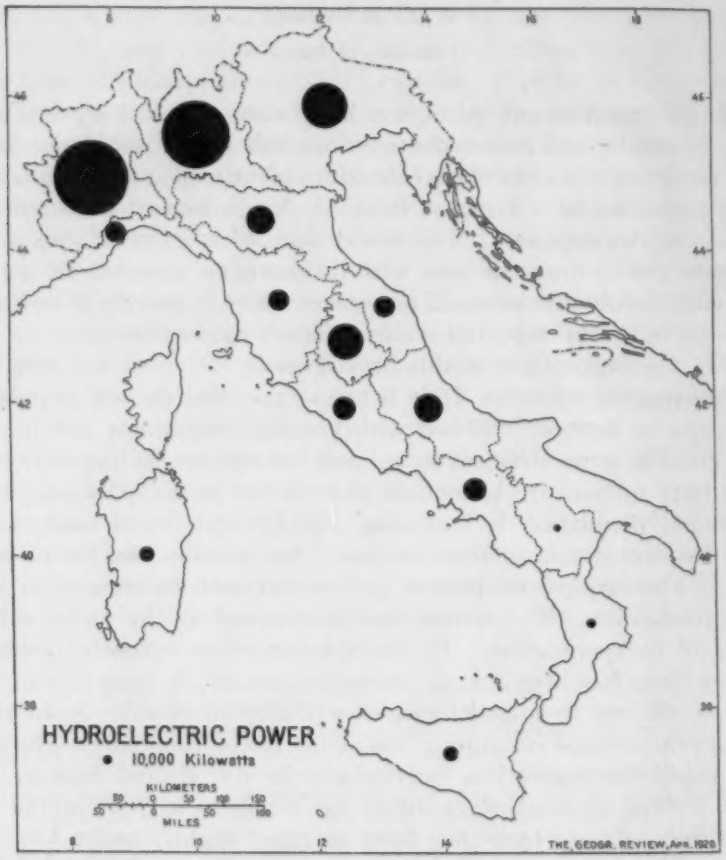


FIG. 1—Installed hydro-electric power of all plants having a capacity of 300 kilowatts or over, December, 1925. Based upon data by Ministero dei Lavori Pubblici, Servizio Idrographico, *Trans. World Power Conference, Sectional Meeting, Basle, 1926*, Vol. 1, p. 360. Scale of map 1:10,500,000.

nite.[2] Practically all of the coal mined comes from Istria in the

[1] Skilled mechanics in Italy now receive a wage equivalent of not more than $1.25 a day; common labor, less than $1.00 (H. C. MacLean in *U. S. Dept. of Commerce, Trade Information Bull. No. 537*, Washington, 1927, p. 12).

[2] G. De Marchi: General Report on the Power Resources of Italy, Developed and Undeveloped (Historical, Economic, Statistical), *Trans. First World Power Conference, London, 1924*, Vol. 1, pp. 944–962. See also J. R. Bradley: Coal in Europe, *U. S. Dept. of Commerce Trade Information Bull. No. 489*, Washington, 1927. Research on her mineral resources has been actively prosecuted by Italy in the last few years and a more optimistic opinion has been expressed by Sig. Belluzzo, Minister of National Economy. See Report on the Commercial, Industrial and Economic Situation in Italy, 1927, Dept. of Overseas Trade, London, 1927. See also A. Baldacci: L'industrie minière et sidérurgique en Italie, *Rev. Internationale*, Vol. 19, 1927, pp. 59–80.

territory newly acquired from Austria, a section whose reserves are estimated at only 13 million tons. Unfortunately it is high in sulphur content and unsuited for many special purposes, including the making of metallurgical coke.

FIG. 2—Diagram showing approximate network of high tension transmission lines linking up the various power stations in Italy in operation and under construction. Italy operated over 45,000 kilometers of high tension transmission lines in 1925. Adapted from E. Vismara, *Trans. First World Power Conference, London, 1924*, Vol. I, pp. 981–1002. Scale of map 1:10,500,000.

The lignite is likewise of poor quality, having a calorific value only one-fifth to one-third of that of soft coal. The location of the deposits also is unfavorable, most of them being in the non-industrial central provinces. Since the cost of the lignite at the mines is only slightly less than that of imported coal at Italian ports, its use is limited to the immediate vicinity of the producing area. The establishment of thermo-electric stations at the mines, begun in 1907, seems to be the practical solution of the problem of their utilization.

By 1924 these plants, already operating or under construction, had a capacity of 70,000 kilowatts. It has been estimated that the total reserves could supply from 150,000 to 300,000 kilowatts for from 50 to 100 years.[3]

During the war the production of coal of all grades was forced up to over two million tons (1918). However, increased freight rates and renewed imports, especially German reparations coal,[4] have caused all the coal mines except those in Istria and the most favorably located lignite workings in Tuscany to close down. In the case of oil the outlook is even less promising, the production of 5000 metric tons annually being about half of one per cent of the nation's consumption.

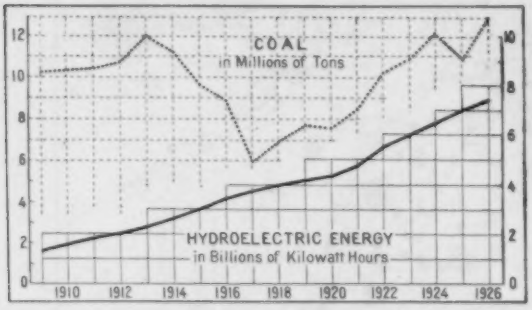


FIG. 3—Consumption of electrical energy in Italy and consumption of coal during the same period. After G. Mortara: Prospettive Economiche, Vol. 7, 1927, p. 308.

WATER POWER DEVELOPMENT

The "silver lining" in the Italian power situation consists in the country's possession of magnificent water power resources; and her record of hydro-electric exploitation, especially since the war, has been a notable one. In the decade following 1914 the capacity of the installed plants was doubled and by the end of 1925 had reached 2.38 million kilowatts, the actual power produced, meantime, having trebled.[5]

As may be seen from Figure 3, the phenomenal development of water power has failed, however, to diminish the coal consumption. Had the power demands of 1925 remained at the 1913 level, the added hydro-electric development and increased oil imports would have reduced the coal purchases by one-half. It appears, then, that the increased exploitation of water power has but kept pace with the industrial expansion, and the coal import requirement of some 11 or 12 million tons must be expected to continue if not actually to increase. The quantity of fuel oil used is so small as to be a negligible factor in the situation.

The rapidity with which the industrial activities of Italy have

[3] *Commerce Repts.*, May 25, 1925, p. 459.

[4] The arrangement by which Italy was to receive reparation coal from Germany was originally regarded as a great boon. However, the agreement calls for delivery f. o. b. mines, and the one-thousand-mile rail haul over the Alps makes it more expensive than imported English coal (A. L. P. Dennis: The Romance of World Trade, New York, 1926).

[5] Ministero dei Lavori Pubblici, Servizio Idrografico, Roma: La produzione di energia elettrica in Italia nel 1925, *Trans. World Power Conference, Sectional Meeting, Basle, 1926*, Vol. 1, pp. 341–358.

been expanded has still another factor in its explanation—the familiarity of the Italian people with the science of hydraulics. Climate and topography—especially in peninsular Italy—coupled with recklessness in deforestation, forced the Italians to an early study of stream control. For centuries the problems of erosion, irrigation, drainage, and city water supply have been of intimate concern to the masses of the population. Likewise the scarcity of wood and the abundance of stone served to develop the art of masonry so that the Italians today are noted for their proficiency in dam construction. It is not surprising, then, that Italy has long been in the vanguard of electrical progress. Nor was it an accident that that country was the first to transmit current in large amounts over long distances—the Tivoli-Rome line having been successfully operated some 35 years ago.[6] Likewise the Florence-Fiesole electric railway was the first to provide such service regularly in Europe.

Northern Italy

Italy's water turbines are about as unequally distributed as are her agricultural activities. The lion's share of both is possessed by the north, for both are the offspring of the Alps. The great fertile plains of the Po are built of alluvium contributed in the main by the Alpine slopes which thus reclaim what was formerly an arm of the Adriatic. The same streams which changed a waste of waters into one of Europe's garden spots are today being harnessed to the wheels of industry located on these same plains. While the plain occupies less than three-twentieths of the area of the kingdom it has three-eighths of the population[7] and in the city of Milan has the industrial metropolis of the country.

Obviously the physical setting of northern Italy is peculiarly well suited to the development of hydro-electric power.[8] The height of the Alps is responsible for a heavy precipitation and for sufficiently low temperatures to maintain extensive snowfields and glaciers and at the same time to furnish a high head for the streams. Many moraine-dammed valleys constitute huge natural lake reservoirs which serve to equalize the stream flow.

The rainfall régime (see Fig. 4), by seasons shows two slight maxima, spring and autumn, and one moderate minimum in winter.[9] However, the seasonal difference is much more marked in the stream discharge. The maximum run-off coincides with the time of greatest

[6] Emirico Vismara: Hydro-Electric Plants in Italy and Their Contribution to National Economy, *Trans. First World Power Conference, London, 1924*, Vol. 1, pp. 981–1002.

[7] Luigi Giannitrapani: La popolazione e i centri abitati della pianura padano-veneta secondo gli ultimi censimenti, *L'Universo*, Vol. 4, 1923, pp. 9–23.

[8] Compare Raoul Blanchard: Geographical Conditions of Water Power Development, *Geogr. Rev.*, Vol. 14, 1924, pp. 88–100.

[9] G. De Marchi: The Italian Organisation for Survey of Rivers: Their Standard Levels and Exploitation, *Trans. First World Power Conference, London, 1924*, Vol. 1, pp. 963–980.

melting of snow and ice, i. e. in summer; the winter flow being less than one-third of that in summer. The Adige with its impermeable basin and its absence of large lakes exhibits a somewhat unusual régime, with a marked summer maximum of precipitation and run-off.

The actual exploitation of water power in different parts of Alpine Italy varies with the local features.[10] Thus Piedmont, in the extreme west, has steep slopes and relatively inaccessible valleys so that the establishment of industrial plants there has been slow.[11] Even where rich iron ores were to be found, as at Cogne, they remained untouched until war time demanded forced action. One of the most interesting developments in this province is the Lake Moncenisio plant. This reservoir impounds over one billion cubic feet of water, and the fall is utilized at two sites, one with a head of five hundred feet, the other thirty-two hundred feet, the highest head plant in Europe. At present Piedmont leads in the number of installations and the power developed.[12]

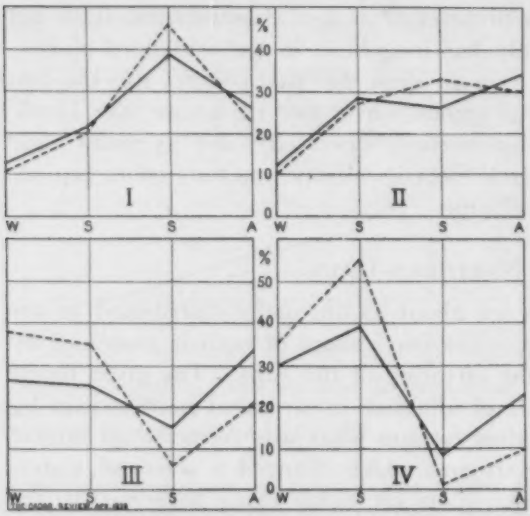


FIG. 4—Seasonal distribution of precipitation (solid line) and run-off (broken line) of typical drainage basins expressed as a percentage of the total annual amount. I, Adige; II, Maggiore; III, Arno; IV, Tirso. Based upon data by G. DeMarchi: *Trans. First World Power Conference, London, 1924*, Vol. 1, p. 968.

Lombardy has a pre-Alpine zone with moderate slopes and a series of finger lakes which serve as great reservoirs so that water power development here is easy. Naturally this has been one of the earliest of the developed regions, textile manufacturing being very important. Recently this section has seen also a remarkable growth in the metallurgical and electro-chemical industries.

Venetia, in the east, its torrential streams uncontrolled by lakes or glaciers, offers the poorest opportunities for hydro-electric develop-

[10] G. Anfossi: L'industrie de la houille blanche en Italie, *Ann. de Géogr.*, Vol. 27, 1918, pp. 196-226 and 388-389.

[11] The southeastern part of the province falls in the Apennine region where conditions are far less favorable for hydro-electric development. See Adele Sandri: La distribuzione delle forze idroelettriche nel Piemonte, *Riv. Geogr. Italiana*, Vol. 30, 1923, pp. 134-149.

[12] Ministero dei Lavori Pubblici, Servizio Idrografico, Roma: Censimento delle grandi utilizzazioni idrauliche per forza-motrice esistenti in Italia, *Trans. World Power Conference, Sectional Meeting, Basle, 1926*, Vol. 1, pp. 359-370.

ment in all the Alpine provinces. The installations are few but are large in size; and, since the province is primarily agricultural, the current is carried long distances to market, chiefly to Venice.

In the newly acquired Trentino, hydraulic development has not yet reached an advanced stage; but projects now under construction promise to transform a hitherto poor mountain region into a moderately prosperous industrial area. Estimates assign to the region a reserve of about 750,000 kilowatts.

The great preponderance of the north in water development is shown in Figure 1. That section accounted for almost three-fourths (72.5 per cent) of the power of plants operating or under construction by the close of 1925. Central Italy had but 16.3 per cent, while southern Italy and the islands had only 11.2 per cent.

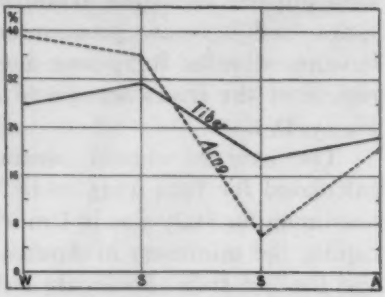


FIG. 5—Discharge by seasons of the Tiber and Arno. The rainfall régime of the two is practically the same. The Arno basin is impermeable, that of the Tiber has one-third of its surface permeable limestone.

CENTRAL ITALY

The northern and central Apennines are less favorable for water power exploitation than even the poorest of the Alpine provinces. The mountains are lower, there is less snow, and there is a total absence of large lakes or glaciers. Furthermore, the climatic conditions are unfavorable—the more so the farther south one goes. Rainfall is smaller, evaporation about twice as great, and seasonable distribution of precipitation less fortunate. Even in the northern Apennines the summer minimum is marked (see Fig. 4, III). River discharge is still less uniform than rainfall. Liguria has an extremely heavy rainfall and perhaps the largest per capita consumption of electric current of the Italian provinces, yet precipitation is most disconcerting in its lack of regularity. At Genoa, for instance, the total rainfall for 1921 was 1763 millimeters; the following year, 522 millimeters; in 1925, 759 millimeters; the following year, 2017 millimeters. For the most part the rivers are torrential and short, many becoming dry beds in midsummer. As a consequence the hydroelectric plants are smaller than in the Alpine region where large streams and fairly even volume justify plants of tens of thousands of horse power each. About one half of all the plants use falls with a head of from 20 to 200 meters, 40 per cent use high falls, 1000 to 1500 meters, and only 10 per cent utilize heads of less than 20 meters.

Again, as in the north, there are marked variations in the river basins. Thus in Figure 5 is shown the effect of differences in the geological character of the watershed. The Tiber and the Arno

have essentially the same rainfall régime, but about one-third of the basin of the former is permeable, while the latter is wholly impermeable. As a result the discharge curve for the Arno closely resembles that of the rainfall, while in the case of the Tiber the stream maintains a much more uniform flow.

Southern Italy and Islands

Southern Italy has remained largely oblivious to the feverish industrial development of the north. It is essentially agricultural with but few industries requiring power. The small annual precipitation and its more pronounced seasonal distribution provide few streams of value for power development. The rainfall and run-off régime of the rivers are much like those of Sicily and Sardinia (see Fig. 3, IV).

The average annual consumption of electricity in Italy was calculated for 1924–1925 to be 176 kilowatt hours per capita. The maximum for Italy was in Umbria, which used 784 kilowatt hours per capita, the minimum in Apulia, Basilicata, and Calabria, the "heel and toe" of Italy, Basilicata only using 4 kilowatt hours per inhabitant.[13] In the use of electricity for light Calabria in 1923–1924 reported a consumption of 2.85 kilowatt hours per capita; Piedmont, 26.7; almost ten times as much, while Italy as a whole averaged 13.7. In electrification, as in the modernization of their agriculture, the provinces of southern Italy and the islands have lagged behind those of the center and north.

However, there are indications of a change, for there is under construction in the Sila Mountains in the "toe" of Italy one of the largest hydro-electric enterprises of recent years. Here artificial reservoirs will provide a total head of over 3000 feet capable of developing some 120,000 kilowatts. The problem of markets is yet to be solved. Calabria, it is estimated, could use 15,000 kilowatts, Apulia 40,000 more; some may go north to Campania, and a transmission line is under construction to carry current across to Sicily. To agriculture in Sicily drought is the big obstacle. If, through local development and imported power, irrigation can be brought to some of her fertile plains, now worthless for lack of water, it will benefit a most needy region. To this end projects are now under construction near Palermo and also near Etna. The Hone reservoir, producing 20 million kilowatt hours and irrigating a large area besides, involved the diversion of the Hone River, whose original outlet was on the southern coast, to the Tyrrhenian side of the island.

In Sardinia conditions are still less favorable. In the whole of that island there is not a single permanent stream. River channels contain

[13] Giorgio Mortara: Prospettive economiche, Vol. 7, 1927, p. 305.

more or less water for about four months of the year, with the volume fluctuating widely from day to day; for the remaining eight months the courses are practically dry. The Tirso basin in the middle west, whose rainfall and run-off distribution are shown in Figure 4, has been known to receive one-half of its annual inflow within a period of 15 to 20 days. As indicated, the rainfall is typically Mediterranean, 70 per cent coming in the winter and spring, while 90 per cent of the run-off occurs in the same period. Uncontrolled, such rivers are more of a liability than an asset either for irrigation or power. Fortunately the topography is favorable for dam construction, and a huge project for the control of the Tirso has just been completed.[14] The works include a reservoir holding 460 million cubic meters, capable of generating 50 million kilowatt hours of current as well as irrigating over 74,000 acres of agricultural land. Incidentally the reservoir also eliminates the necessity of maintaining costly dikes built along the lower course as a protection against flood.

Ironing Out the Energy Curve

Of the various handicaps to hydro-electric development in Italy, lack of uniformity in the flow of the rivers is apparently one of the most serious. This difficulty is, as we have seen, greatest in the south. Three methods of ironing out the inequalities in the discharge curves are commonly used. They are: (1) artificial reservoirs, (2) auxiliary stream plants, and (3) the linking up by transmission lines of the regions with different energy régimes.

The high cost of coal makes operation of thermal auxiliary plants expensive. They are, however, used to some extent, especially in central and southern Italy, where they make up as much as one-fourth of the total. In northern Italy they contribute less than three per cent. For the country as a whole the installed capacity is about 20 per cent steam; but most of the installations were for reserve. Of the actual power generated, steam is estimated to account for only about five per cent of the total.

The use of reservoirs has always been an important feature of Italian hydro-electric development and will naturally become more so as the less desirable projects are exploited. However, the variations in Italian rainfall are so wide that artificial storage sufficient to care for the more unusual or extreme fluctuations is often more expensive than steam plants. The rainfall of Italy for the two years 1923–1924, for instance, is reported as being 30 per cent below normal, so that plants already installed were not able to run to capacity. Even at Milan a rainfall record of over 150 years shows, for example, a variation

[14] Marcello Vinelli: Water Conservation in Sardinia, *Geogr. Rev.*, Vol. 16, 1926, pp. 394–402.

in October precipitation from 376 millimeters to 4.8 millimeters.[15] Steam plants have the additional advantage of providing insurance against interruption of essential services, such as electric railways, in case of accident to the hydro-electric plant or dam failure.

Figure 4, showing the variations in the stream discharge curves in different parts of Italy, immediately suggests the obvious advantage of connecting up the different regions. Thus the power deficiency in the north during the Alpine winter could be made up by drawing current from the northern Apennines. How effectively the two supplement each other may be seen from Figure 6. Rapid absorption of small plants by large corporations has facilitated linking together the latter, and today Italy may be said to be practically covered by a network reaching from the Alps to Sicily (Fig. 2).

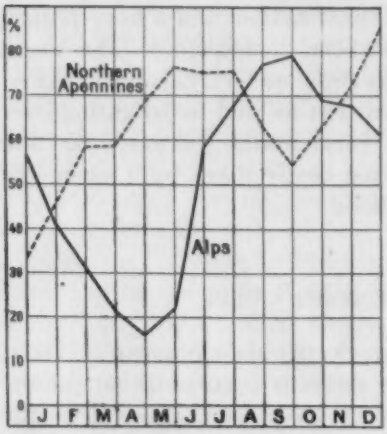


FIG. 6—The hydraulic energy régime for 1925 in the northern Apennines and the Alps. Note the complementary character of the curves: the advantage of connecting the two so as to get a more even flow of current is apparent. Adapted from *Trans. World Power Conference, Sectional Meeting, Basle, 1926*, Vol. 1, p. 351.

MARKETS FOR ELECTRICITY IN ITALY

For what purpose is the electric energy used? As indicated in Figure 7, the greater part finds its way to mills and factories. Actual distribution of the total output among the various groups of consumers does not differ from north to south as much as one might expect. There is, however, a growing tendency for more marked regional differences in the chief use of the available power. Thus in the northern and central provinces power development continues to be primarily for industrial purposes, agricultural benefits being largely incidental. In the south, however, including Sicily and Sardinia, the proposed schemes are giving much more attention to the agricultural aspect. The relatively greater importance of farming as an occupation and the less favorable rainfall conditions in the south are serving to emphasize the agricultural benefits accruing from the utilization of available streams. Construction of dams and reservoirs may be planned not only to provide irrigation during the summer drought but also to facilitate the drainage of extensive areas normally subject to winter floods. This bears directly not only upon the area

[15] G. Motta: The Coexistence of Hydro-electric and Steam-Driven Generating Stations as Affecting the Economy of Production and the Necessities of Storage and Reserve. *Trans. First World Power Conference, London, 1924*, Vol. 2, pp. 238–250.

of tillable land but on the question of disease control in a region long notorious for malaria. Actual electrification of agricultural operations, outside of irrigation and drainage, has been slow in Italy, much slower in fact than in France and Sweden. Cheap labor, conservatism, and ignorance, especially in the south, militate against change.

Of the various types of manufacture one would expect Italy to specialize in those in which power and labor were large elements of cost, raw materials a relatively small item. Metallurgical industries require much, the textiles relatively little power in proportion to the value of the output. However, though textiles require much labor, their high value makes transportation of the raw material a minor item. The situation of the metallurgical industries is just the reverse: the labor factor is small, but the cost of transporting ore and metal is large. As a consequence textile manufacture has played a large rôle in Italian industry. Metallurgical plants have been expanding in spite of, rather than because of, favorable geographical conditions. The world's output of electric steel dropped about 50 per cent from 1918 to 1922, but that of Italy more than doubled in the same period. The increase is due chiefly to the importation of scrap steel, whose use as the basic raw material reduces the power cost by four-fifths, but the industry can hardly compete with that in Germany or Britain without government support.

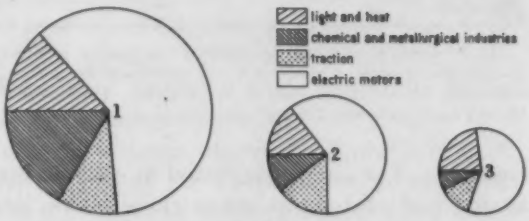


FIG. 7—Energy consumed by régimes in 1925: 1, Northern Italy; 2, Central Italy; 3, Southern Italy and Islands. The total consumption in 1925 was about 7.5 billion kilowatt hours: of this, 15 per cent for light and heat; 60 per cent, motor power; 11 per cent, railway traction; 14 per cent, for metallurgical and chemical industries. From *Trans. World Power Conference, Sectional Meeting, Basle, 1926*, Vol. 1, p. 357.

The actual location of the manufacturing units is in marked contrast with their distribution in the regions of coal. Factories are scattered throughout the Po basin, often situated in the open country, perhaps in a wheatfield or mulberry grove. True, such cities as Milan, Turin, and Genoa are important industrial centers; but there are nowhere to be found the highly concentrated manufacturing districts such as are characteristic of the coal fields of Germany, Britain, or the United States.

Economic and Political Aspects

It is interesting to note that Italian hydro-electric development has been sponsored mainly by private capital and initiative. Securities of water power companies are generally regarded in Italy as safe investments yielding moderate returns. In 1923 the average profits

of 131 such companies were 6.75 per cent. The government maintains strict control over the development; and concessions are made, at least theoretically, on the basis of merit rather than priority. Further to aid the work there is a hydrographic service which gathers statistics and collects observations from some 5500 stations of various types, including 3800 rainfall and 850 hydrometric stations. A government subsidy of 60 lira per horse power for plants already operating or in an advanced stage of construction to be effective December 31, 1928, has been promised for southern Italy, Sicily, and Sardinia, and one of 40 lira for the rest of the country. The capital invested in electric installations was estimated at the end of 1924 as about three billion lira. Thus it may be seen that the state tax of about nine per cent on the capital nets the government a considerable income.

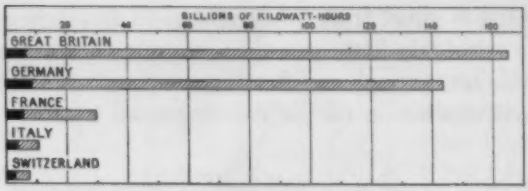


FIG. 8—Power theoretically available in coal and oil production plus that from water power, potential (ruled) and exploited in 1920 (solid black). Data from P. A. M. Nash, *Trans. First World Power Conference, London, 1924*, Vol. 4, p. 1311.

ITALY'S ELECTRICAL STATUS

By the close of 1925 there were all told 588 hydraulic plants operating in Italy. Their installed capacity of over two million kilowatts was larger than that of any other country of Europe. Furthermore, development was still active. Some seventy-nine plants, representing over a million horse power, were under construction.[16] This alone would mean an increase in the total capacity of over 40 per cent in the next few years even if no further exploitation were begun. In addition reservoirs designed to impound 770 million cubic meters of water were being built. The actual saving in terms of coal due to hydro-electric development was estimated in 1924, on the basis of 6.5 billion kilowatts of energy produced, as equivalent to 6.5 million tons, a quantity equal to about one-half of the present annual import.

It may well be asked how much farther the curve of water power exploitation can rise. One estimate, analyzed in Figure 8, gives the amount of energy theoretically available based upon the annual coal and oil output plus the water power, both potential and exploited, in 1920. Italy is shown as consuming about one-third (32.1 per cent) of her total power theoretically available. Both Italy and Switzerland (36.2 per cent) appear to be nearing the limit, assuming that perhaps

[16] *Commerce Repts.*, April 18, 1927, p. 159.

50 or 60 per cent of the theoretical power may be actually capable of practicable exploitation.

A second estimate, admitted as only roughly approximate, gives the maximum possible hydro-electric power as 14.3 billion of kilowatts. This, the same authority says,[17] would be equivalent to the power obtained from seventeen million tons of coal, or about one and one-half times the maximum coal consumption of Italy for any year up to date.

Comparative costs of water power exploitation have shown a marked tendency to increase. Thus from 1918 to 1924 the cost as measured by the capital investment per kilowatt of plant capacity advanced almost 100 per cent. Naturally, the sites requiring the least expenditure were the first exploited, and the less desirable ones are being developed only with greatly increased investment. It is for this reason that perhaps only 50 to 60 per cent of the power theoretically available may be actually exploited.

In the face of this situation it seems inevitable that there must come very shortly a flattening out of the water power development curve. That change will be hastened as other countries more richly endowed with coal and raw materials, e. g. Germany and France, recover and competition becomes still keener. Italian industry will trend more and more to the types of highly finished goods into whose make-up the labor cost will be a still larger element. One may expect, for example, less raw silk and more manufactured silk garments to figure in her export trade. There is no basic reason why Italy should not complete the whole manufacturing cycle instead of sending the raw silk to be worked up in Switzerland, France, or the United States.

[17] I. C. Funk, *Commerce Repts.*, May 25, 1925, p. 460.

THE DISTRIBUTION OF POPULATION IN NYASALAND

F. Dixey

Government Geologist, Nyasaland Protectorate

RECKONED by African standards the native population of Nyasaland is large. According to the 1926 census[1] it is 1,290,885, giving an average of 34.6 per square mile, whereas for Tanganyika Territory the density is 11.26, for Northern Rhodesia 3.2, for Southern Rhodesia 5.1, for Portuguese East Africa 7.0. Distribution, however, is uneven. The total area of the Protectorate is about 37,890 square miles, and the population is disposed over it about as follows:

Population Per Square Mile	Area in Square Miles	Percentage Area
201 and over	810	2.3
151–200	480	1.4
101–150	1845	4.8
51–100	5150	13.5
11–50	8350	22.0
0–10	21255	66.0

The areas of densest population are in the Lower Shire valley about Port Herald and the Chiradzulu district and adjacent parts of Blantyre where the native population is over 200 to the square mile. More than one-third of the European population (1656 in 1926) also lives in the Blantyre District, which contains the commercial centers of Blantyre and Limbe; and a little more than one-seventh lives in the Zomba District, which contains the seat of government and also has a large native population. On the other hand the figures show two-thirds of the country with less than 10 inhabitants to the square mile. The northern Nyasaland plateau, for instance, is very sparsely populated. Moreover, this section suffers great losses by the continuous emigration of natives to Rhodesia and South Africa. At the time of the census taking it was estimated that 30,000 Nyasaland natives were absent in these countries; but it is to be hoped that with better farming

[1] This discussion and the map of population density illustrating it are based principally upon the 1926 Census Report of Mr. S.S. Murray; to some extent also it has been compiled from the information collected by Mr. Murray in connection with the Report, as well as from observations I have myself made from time to time.

opportunities in their own country this exodus of the natives will gradually grow less.

Population and Water Supply

In the following discussion of distribution emphasis will be laid on the question of water supply, which is intimately bound up with a number of population problems. Such problems include the relief of congested areas; the transference of native villages from areas infested with tsetse fly; the extension of native industries, including the growing of tobacco, cotton, and food crops, and the raising of cattle; the control of emigration; the settlement of labor required on European estates; the extension of forest reserves; and the control of health.

In the Report of the Lands Commission appointed in 1920 due emphasis is laid upon the necessity for providing water in a number of dry areas that are otherwise suitable for settlement. In general, water is not so much needed for agriculture, for which the rainfall is usually sufficient, as for domestic purposes; and this is demonstrated by the alignment of habitations along a network of streams even in areas of uniform soil. Investigation has often shown that supplies for domestic use can be developed at small or moderate cost and that ground-water supplies can often be tapped by means of boreholes and windmills; furthermore, in other areas supplies suited to irrigation purposes are available.

The urgency of the problem is in no small danger of being overlooked for a time owing to the generally improved condition of the streams and of subsoil moisture during the last three years. Owing to the cyclic variations of climate known to affect this part of Africa, these ameliorated conditions may safely be regarded as temporary, and within a few years abnormally dry seasons similar to those of 1920–1924 will doubtless again be experienced. When such a dry period does recur, greatly increased difficulty as to native and other water supplies will very possibly be met as a result of the intervening deforestation and soil erosion. On this point the Census Report is emphatic.

> In many parts of the Protectorate the natives have denuded the land of trees with the natural consequence that streams which formerly ran with reasonably pure water throughout the year have dried up entirely or partially, and the quality of the drinking water, which is often stagnant, has deteriorated enormously. The result has been a notable increase in the incidence of intestinal complaints. . . . It will take many generations to repair the damage that has been caused by the ruthless destruction of forest, even if the evil is reparable at all. In the meantime the water supply of the natives constitutes a serious problem from the point of view of health and the prevention of mortality. The remedy would seem to lie in the construction of village wells, adequately protected from pollution.

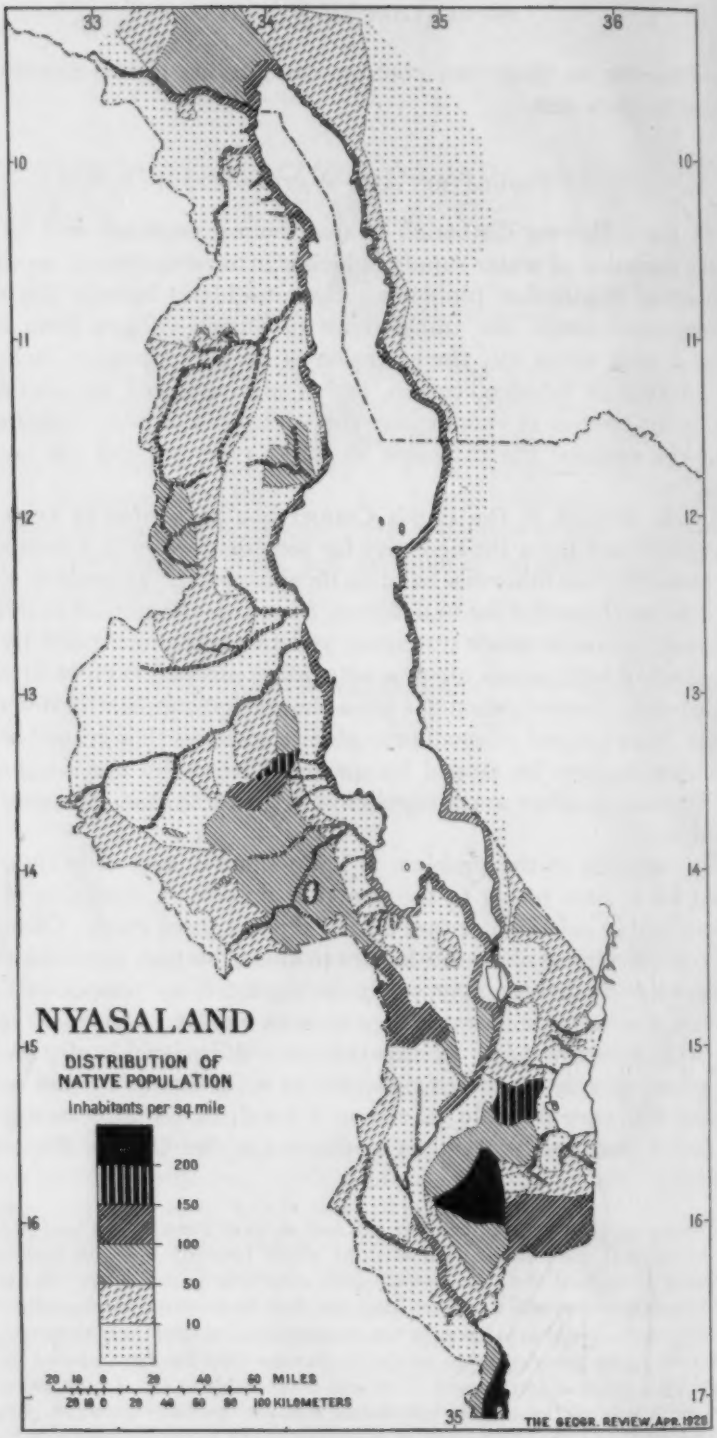


FIG. 1—Map of Nyasaland showing distribution of native population according to the census of 1926. Scale of map 1:4,625,000.

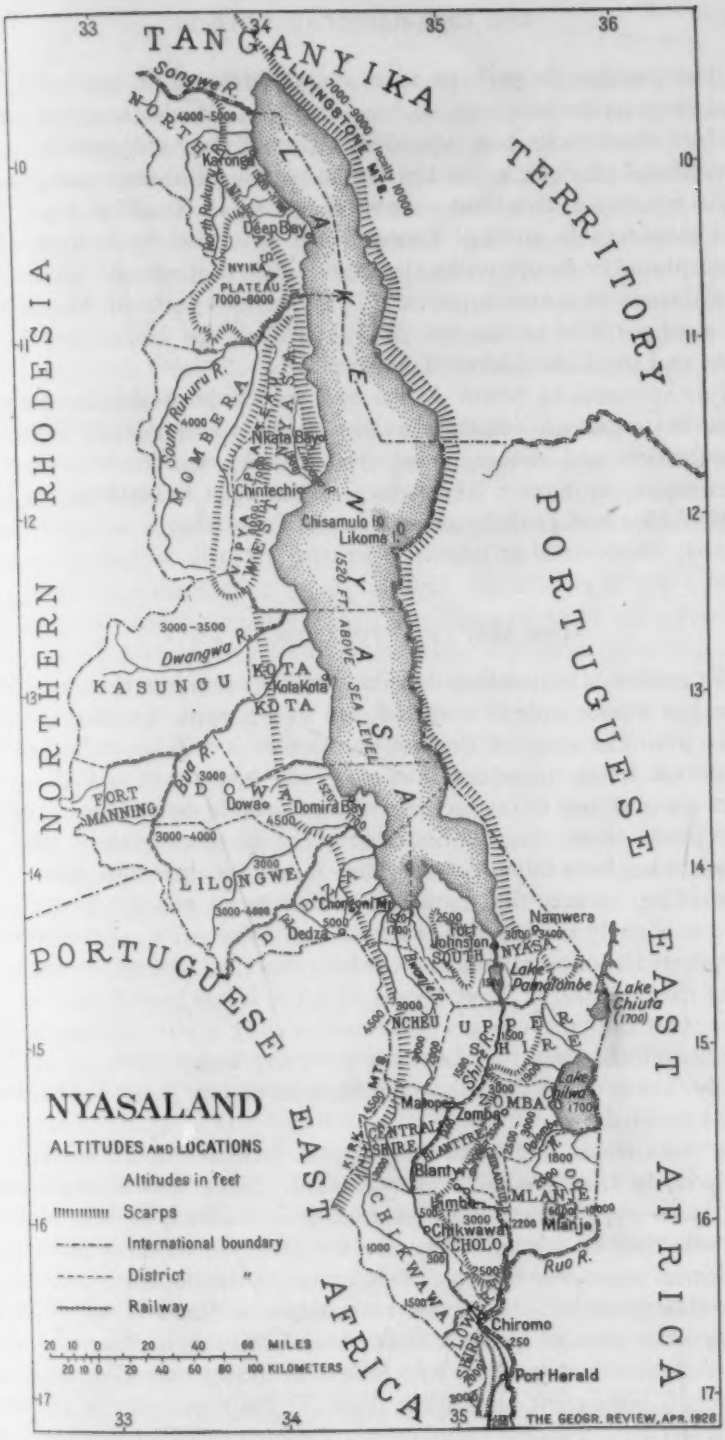


FIG. 2—The main physiographic divisions of Nyasaland are defined by hachures and by approximate elevations.

The problem is perhaps more clearly defined in territories that have large native reserves, such as Southern Rhodesia, which during the last three years has expended approximately £20,000, exclusive of overhead charges, upon the water supply of these areas. While native reserves of this kind are not recognized in Nyasaland, yet there exist considerable areas of Crown lands inhabited by natives which would probably amply repay the expenditure of moderate sums in the development of water supplies. They include parts of Angoniland, the southern lake plains, the Bwanje valley, the Upper and Lower Shire, and the Lake Chilwa-Tuchila plain.

Furthermore, in South Africa and in Rhodesia the Government assists in various ways in the provision of water boreholes for European agriculturists and in some cases even makes preliminary trials as to water supply on Crown land before alienating it to settlers. In 1922 South Africa had 40 drills at work, and this number is now greatly increased; Rhodesia is at present operating 10 drills.

The Map of Population Density

Six grades of population density, ranging from less than 10 inhabitants per square mile to over 200, are shown upon the map (Fig. 1). Apart from the areas of densest population it will be seen that the population tends to concentrate along the lake shore and along the larger streams and rivers; in view of the variable densities attained in these places, however, combined with the narrow strips of land involved, it has been found necessary to employ for them a uniform average shading, namely that indicating a density of 101–151, and to exaggerate slightly the breadth of the strips. Where it has been possible to evaluate the population along the lake shore, as around the southern end of the lake and in West Nyasa District, it has been found, on the assumption that the villages concerned occupy a strip averaging two miles in width, that the densities generally range from 90 to 200. Locally, however, as also along the Shire in places, these densities are much exceeded.

In the Census Report the population densities in the sections of certain of the Districts had been evaluated. Since these sections range from 17 to 2978 square miles in area, it is evident, as Mr. Murray observes, that as a whole they are too large to serve as units in a population map. For example, a statement of the population densities of the three sections forming the western side of South Nyasa District affords little clue to the fact that the inhabitants are concentrated mainly along the water side, with a density locally exceeding 200, and to a much less extent on Chilipa plateau; the remainder of the area is thus left with a sparse population, averaging considerably less than 10 to the square mile.

Figures are available[2] showing the native population of the sub-districts of southwestern Tanganyika, of which the average density is 8.7. Although details as to the different parts of the sub-districts are not given, it would appear that along the greater part of the lake shore south of Konde Land there is a narrow densely-populated strip, followed by a narrow lake plain and a scarp (or a scarp only along the Livingstone Mountains) of low density and thence by plateaus with densities of only about 6 to 13, and 13 to 26; these conditions roughly correspond to those of Nyasaland on the opposite side of the lake and would appear to be similar also to those of Portuguese territory along the southeastern shore of the lake.

In the Lower Konde sub-district of Tanganyika, however, along the northernmost shore of the lake between the Songwe River and the Livingstone Mountains, conditions are very different. In this sub-district, with an area of about 380 square miles, the population density approaches 100.

The average number of inhabitants in the villages of the various districts in Nyasaland ranges from a minimum of 57 in Blantyre to a maximum of 259 in South Nyasa; there are only 18 villages with over 1000 inhabitants and only 86 with 500 to 1000 inhabitants. Kota Kota township is formed of a number of villages with an aggregate population of 5438, mostly concentrated within an area of about one square mile. Mponda's village near Fort Johnston is the largest individual village and has a population of 2562. There are only three districts, namely West Nyasa, South Nyasa, and Lower Shire, with any considerable number of large villages. In all three the most fertile areas lie in strips along the river valley or lake shore, and it is not easy to find an unoccupied site.

Physical Divisions and Population

Side by side with the population map is a map showing in diagrammatic form the principal physiographical features of the Protectorate (Fig. 2).[3] The country is traversed from end to end by a deep, broad trough that represents the Great Rift Valley in this region; accordingly, it may be regarded as consisting of three principal features: the floor of the Rift Valley, partly occupied by Lake Nyasa and by the Shire and its tributaries; the scarps forming the walls of the rift, frequently very steep or even precipitous; and the plateaus that border the rift and make up the country on either side. The scarps, as well as certain of the higher plateaus and mountain masses, are roughly indicated upon the map. A branch of the rift runs south-southeast-

[2] C. Gillman: South-West Tanganyika Territory, *Geogr. Journ.*, Vol. 69, 1927, pp. 97–131; reference on p. 118.

[3] See F. Dixey: The Nyasaland Section of the Great Rift Valley, *Geogr. Journ.*, Vol. 68, 1926, pp. 117–140.

wards from Lake Malombe to Lake Chilwa and thence past the western side of the Mlanje Mountains and along the course of the Ruo valley.

It is significant that, apart from the Shire Highlands, where a number of artificial factors have helped to develop a dense population, the more densely populated areas on the plateaus and scarps largely coincide with the outcrop of the graphitic gneiss and crystalline limestone series of the crystalline rocks;[4] these areas comprise that part of Angoniland between the southern boundary of Kota Kota District and Dedza, the upland areas bordering the Rift Valley between Dedza and Neno, and the country west of Port Herald.

West and northwest of the graphitic and related gneisses of the southern and eastern part of Angoniland there extends a wide plateau of about 4500 square miles underlain by granites, granulites, and acid gneisses; the disintegration of these rocks has given rise to a great expanse of pale, very sandy soils and subsoils, dry and sterile, that are in great contrast with the red, fertile soils of the graphitic gneisses. Just as these latter soils support the densest population of this region, so the dry sandy soils of the west underlie the largest sparsely populated tract in the whole Protectorate. The somewhat better population of these acid and intermediate gneisses when they are followed northwards to Mombera is probably due to the influence of the Vipya and Nyika plateaus, which enjoy better rainfall and give rise to the South Rukuru River and its numerous tributaries.

The outcrops of the older sedimentary formations are almost wholly unpopulated. These include the Karroo running along the Portuguese border west of Chikwawa and Chiromo, which covers an area of about 800 square miles and consists mainly of sandstones and grits; the quartzites, sandstones, and related rocks of the Mafingi Mountains; and the Cretaceous and Tertiary sandstones and marls that occupy considerable areas between the Songwe River and Florence Bay. The sandstones of the various Karroo outcrops of North Nyasa are also almost unpopulated; contrasted with these the calcareous and clayey rocks of the same period, as in the Nkana and Mpata areas, are well populated; this is doubtless because these latter rocks not only yield better soils but also, owing to a lower resistance to erosion, have formed depressions that receive a fair supply of water from the adjacent uplands.

Wherever the larger alluvial areas are adequately supplied with water they support dense populations, like the populous tracts of Konde Land at the northern end of the lake, those of South Nyasa and the mouth of the Bwanje valley at the southern end, and also other alluvial areas around the lake, as well as in the Lower Shire and the valleys of the larger rivers.

[4] See F. Dixey: The Geology and Mineral Resources of Nyasaland, *Mining Mag.*, Vol. 34, 1926, pp. 201–212.

The distribution of population by the various physiographic divisions will now be examined in some detail.

The Lake Shore

The term "lake shore" is here used to describe the populated strip of land around the margin of the lake. It is generally about two miles wide but much narrowed where the mountains come down to the lake, as in West Nyasa District. Its high density is doubtless essentially due to the ease with which water and food can be obtained, for not only is fish always available and the curing of fish for sale an important local industry but also two crops of maize can be raised in the year.

Along the Konde coast, north of the Songwe River, the dense population merges into that of the plains behind. The inhabitants of North Nyasa District are largely concentrated along the lake shore. In West Nyasa District 80 per cent of the population lives near the shore, along a large part of which there is a continuous line of huts. The steep mountain slopes here are characteristically continued far below water level, so that the shore platform is discontinuous and largely confined to narrow beaches within a number of small inlets. For instance for a distance of more than ninety miles north of Chintechi there are only two satisfactory anchorages for the lake steamers, namely at Nkata Bay and Ruarwe.

That part of the coast near the northern part of Kota Kota District supports relatively few people, apart from Kota Kota township itself. Southwards, however, the population density tends to increase, so that around the southern end of the lake, on the assumption that the villages occupy a strip two miles wide, it varies from 100 to 200 per square mile, the maximum being reached around the extreme southeastern part near Fort Johnston.

One other part of the lake shore is of interest, namely that around the islands of Likoma and Chisamulo. The total population of these islands, which probably do not exceed 10 square miles in area, is 8818; and, while the average density is therefore great, the actual density along the coast is even greater. This concentration is due to the almost complete absence of vegetation, soil, and water in the interior part of the islands. When they first came under European influence, only about forty years ago, they were well wooded and well watered; now, not only are most of the gardens of the islanders situated on the mainland, but even firewood and poles for huts have to be carried thence across to the islands.

The Lake Plains

The lake plains are highly important for their economic possibilities. They lie principally at the extreme northern and southern

ends of the lake and along the western side except where the mountains of West Nyasa rise almost directly out of it. Along the eastern side the lake plains are rarely more than three or four miles in width, and in several places, as along the foot of the Livingstone Mountains, they are absent altogether.

The population of the Konde plains at the northern end of the lake is much higher than that of any other area of similar extent around the lake shore; this is doubtless owing to the breadth and character of the soils that overlie the floor of this part of the Rift Valley and also to the high rainfall—60 to 75 inches per annum. The soils and subsoils of the area are mainly alluvial, and their high fertility is in part due to their derivation from the alkaline lavas and ashes that lie between Rungwe and the Songwe River. Konde Land will doubtless prove to be of great economic importance when Lake Nyasa is finally connected to the sea by rail.

The section of the plains extending from the Songwe River to Florence Bay is about ten miles in average width, although west of Karonga, if the Mwesia valley be included, it is considerably wider. The inner margin of the plain, where it approaches the foothills of the main scarp, is broken by several ridges of crystalline rocks that run parallel with the lake shore; the country between and immediately on the eastern side of these ridges is made up of innumerable steep-sided hills and tables of sandstones, marls, and gravels (the Dinosaur Beds and Tertiary sediments), almost entirely waterless and sterile, apart from a few small patches of alluvium in the valleys. The soils and subsoils are almost invariably coarse and gravelly besides being frequently overlain by a sheet of pebbles and boulders. Apart from the fact that the valleys support a number of cattle and that the sediments contain many deposits of limestones suitable for agricultural and building purposes, the area appears to be of no economic value.

East of this dry, stony, and sterile country, however, an unbroken strip of alluvium stretches from the Songwe to Deep Bay; it is six miles in average width and 60 miles in length and has considerable economic promise. Since the plain has been built up partly from deposits laid down by a number of rivers that traverse it and partly by the action of the lake itself, which has subsequently receded to its present position, it follows that the character and quality of the deposits will vary from place to place and permit the cultivation of a wide range of crops. The soils are usually light and sandy, but they range for the most part from gray and brown medium loams to fine sandy loams; locally, however, they may be clayey or even coarse and pebbly. They are not often deficient in lime, and numerous deposits of limestone are available in the area.

Cotton was grown on the plain until about two years ago, when, owing to the encroachment of the pink boll worm from Tanganyika

Territory, this crop had to be abandoned in order to save the cotton areas of southern Nyasaland. The plain has recently been shown by the agricultural chemist to be thoroughly suitable for the production of tobacco, both bright and dark, and it is probable that this will soon become the principal crop. Bananas form the main food crop along a large part of the coast, but rice is grown locally. Other crops that can be successfully grown include sorghums, maize, millets, beans, peas, cassava, sweet potatoes, sesame, and groundnuts, as well as many grasses of high feeding value.

The population over a large part of the plain averages 30 to the square mile, but it is almost exclusively confined to the lake shore and to the banks of the half dozen rivers that cross the plain. Considerable areas are wholly uninhabited mainly for lack of water. Only the larger rivers, the Songwe and the Northern Rukuru, maintain a steady flow throughout the year; the smaller streams dwindle and disappear after leaving the foothills, although in some cases water can be obtained by excavating in their sandy beds. The interfluvial areas are completely arid for the greater part of the dry season, yet if water were made available upon them they should become as productive as the present well watered areas.

But from the point of view of underground water supplies better conditions could scarcely be desired, since the plain is built up of alluvial deposits that are inclined very gently lakewards from the foot of high plateaus, and the rainfall varies locally from 30 to 50 inches per annum. The inner margin of the alluvium stands at about 160 feet above lake level, and this probably marks the maximum depth at which water would be obtained. Although much could be done locally by means of excavated wells, the depth of the water table and the friable nature of the alluvium would render the work difficult, and conditions on the plains are not suitable for the construction of small earth dams. Boring would afford the easiest and most satisfactory means of obtaining water. It should be remembered that the sedimentary layers of which the plain is built up are probably lenticular in form, so that sub-artesian conditions may be expected to exist.

Mention should be made of the admirable sites for dams in the country immediately behind the alluvial belt. From the point of view of the volume of water that could be impounded per unit cost these sites probably include some of the best in the Protectorate. It has already been mentioned that this belt comprises several crystalline ridges. Through the outer ridges the rivers have cut deep, narrow gorges where easily constructed dams would impound enormous quantities of water that could be used for irrigation.

Included within the lake plain is the Limpasa *dambo* (an open plain) and the low country lying between it and Chintechi. The

dambo stands but little above lake level, probably less than 150 feet, and on the gentle slopes rising 100 to 300 feet above it stand rubber estates of the African Lakes Corporation. This area, including that traversed by the Luweya and its tributaries, is, apart from the lake shore, the best populated area of its size in northern Nyasaland, doubtless because of its deep rich soils and the high rainfall induced by proximity to the Vipya Mountains. The rainfall, which ranges from 70 to 100 inches per annum, is probably higher than that of any other area in the immediate vicinity of the lake and is more evenly distributed than is the case in most other parts of Nyasaland. The area is exceptionally well wooded. Rubber is grown with considerable success, and parts of the district are considered to be suited to growing of tea and coffee, and it is expected that great expansion will take place as transport conditions improve.

The next part of the lake plain to be described is that traversed by the lower course of the Dwangwa River and that lying behind Kota Kota; possibly also similar conditions prevail between these two places. These areas, together with that lying behind Fort Maguire for a distance of about twelve miles to the foot of the main scarp, are essentially different from the alluvial areas so far described in that they consist of planed-off rocky platforms that slope gently down to the lake shore; solid rocks underlie them at a depth usually of only a few inches, and the soils and subsoils when present are coarse and gravelly. These conditions are similar to those of a large part of the floor of the Shire valley.[5] Such areas are unpopulated like other parts of the lake plain but, unlike them, owing to the absence of good soils as well as water, do not offer any hope of economic improvement.

The remaining part of the lake plain extends to the southern end of the lake and includes the lower Bwanje valley and the lowlands about Fort Johnston; this tract is wholly alluvial and includes some of the best land near the lake. Behind Domira Bay it is about 20 miles in width, south of this somewhat narrower. It closely resembles the North Nyasa coastal plain in general character and economic possibilities, except that it has the additional advantage of being within reach of prospective railway development. As in the case of North Nyasa the population is mainly confined to the lake side and the banks of the larger rivers but is much greater and denser than that of the northern area. The soils of this area are sometimes of extraordinary fertility, for example the land between Ntakataka (Dedza District) and the mouth of the Bwanje, which has been cultivated continuously for many years and usually produces two annual crops of maize. The northern part of the area, particularly in Kota

[5] See F. Dixey: The Physiography of the Shire Valley, Nyasaland, and Its Relation to Soils Water Supply, and Transport Routes, *Rept. Geol. Survey Nyasaland*, Zomba, 1925.

Kota and Dowa districts, produces much rice, while the southern part is yielding tobacco at a rapidly increasing rate; cotton can be grown over a large part of the area.

The water supply conditions are similar to those of North Nyasa, and here also probably some hundreds of square miles could produce valuable crops if only the underground water supplies were made available. When streams are in process of absorption by the alluvium the water table is a convex surface of which the stream bed forms the uppermost part; consequently, wells put down only a short distance from the stream channel may have to penetrate considerably below the level of the stream before striking water. North of Ntakataka, several miles from the lake shore, two wells were excavated to depths of 90 feet; one struck a little water, the other remained dry. Yet where the land within two or three miles of the lake shore is very low, perennial water may be met at depths of 30 feet or less. Along the inner margin of the plain at a distance from river channels the water table may lie as deep as 150 feet; but, though inaccessible by excavated wells, it could easily be reached by boring.

The Scarps and Plateaus West of the Lake

The scarp that rises from the inner margin of the lake plain to the plateau above does not call for much comment. Usually, owing to its steepness, dryness, and general rocky character, it is practically uninhabited, even where, as in Dedza District, the plateau area immediately overlooking it is well populated. But where streams emerge at the foot, as along the base of the Vipya Mountains, or where the scarp rises directly out of the lake, as in part of West Nyasa District, there the lower slopes may support a small population. If the scarp is not too steep, however, or if it descends in steps to the lake plain, then quite a dense population may exist, as along the Nchisi Hills in Kota Kota District and for a short distance southwards into Dowa District.

With the exception of southeastern Angoniland and the southwestern corner of Mombera, the population of the plateaus west of Lake Nyasa is very small; apart from the areas named, about half the plateau has a population density ranging from 21 to 26, with one section of Fort Manning District reaching nearly 30 while the other half has a density of less than 10. The Nyika plateaus, covering an area of about 900 square miles and standing at 7000 to 8000 feet, and the Vipya plateau and its northern extension, covering about 1100 square miles and attaining to 6000 to 7000 feet, are both entirely uninhabited.

There can be no doubt that the increasing cold of the higher altitudes, combined with the difficulty of raising essential food crops,

is the main reason for the sparse population. The natives strongly dislike the thick mists and drizzling rain that frequently occur at high altitudes for several months in the year. They are unable to withstand the inclement weather largely because they are usually ill-nourished and ill-clad. Tribes differ widely in this respect, however; in the Livingstone Mountains the Wakinga people carry their villages up to heights of more than 8000 feet.

Areas in Nyasaland lying at 4000 to 6000 or 7000 feet need not necessarily remain with little or no population, however, especially where soil and water conditions are satisfactory. Such areas are often thoroughly suitable for European settlement; and it has been the experience in Kenya, in Tanganyika, and to a less extent in Nyasaland that natives tend to follow Europeans to the higher altitudes when suitable provision is made for them.

Mombera is less sparsely populated than the remaining plateaus of northern Nyasaland; the average density for the greater part is 21, but in the southwestern corner this increases to a maximum of 78 in one small section. This is perhaps due to the nearness of the highlands which give rise to a number of perennial streams, while the more densely populated area of the southwest is traversed by the headstreams of the Northern Rukuru and some of its tributaries.

Parts of Mombera afford instructive examples of the great injury that can be done by the indiscriminate destruction of bush. For example, the Kasitu valley, in the opinion of local missionaries of long experience, is passing to desert conditions. Formerly, the area was well wooded, well watered, and densely populated; but in the past few years the Angoni have deforested it by their wasteful methods of cultivation. There is now scarcely a tree of moderate size to be seen, soil erosion is proceeding apace, water is extremely scarce, and the population has migrated in search of moister conditions. In a lesser degree this is true of the country east of Mzimba below the Vipya, and also of that lying north and west of Ekwendeni. Denudation of these areas is so far advanced that even under the strictest control recovery must be very slow.

Referring to the district as a whole the Resident has stated that in the dry season water is very scarce, and the people have frequently to walk miles from their villages to obtain it from the sandy beds of streams. This is important since Mombera forms with North Nyasa a very important cattle area, the two districts containing half the cattle of the whole Protectorate. In ordinary circumstances a shortage of water is bad enough, but in a cattle country it is incomparably worse.

It is expected that with improved transport an important industry in hides and skins will develop in the northern part of Nyasaland; but in many areas, particularly in Mombera and northern Kasungu, it

will be restricted by the shortage of water unless steps are taken to preserve and develop the supply. In many cases a beginning can be made by the excavation of wells and the building of earthen dams, the success of which has been demonstrated by the mission stations at Loudon and Kasungu; but in the flatter and more open areas boring will have to be undertaken.

As regards east-central Angoniland, the densely populated tract west and north of Dowa lies mostly from 3000 to 4000 feet, while the less densely populated area immediately to the south also lies mainly from 3000 to 4000 feet, except near Dedza and along the western margin, where it locally reaches 4500 feet. Dedza itself stands at 5000 feet, and this is the highest inhabited part of the district; nevertheless, many of the natives now living there are attached to the various European stations, although the area was populated and to a great extent cleared of timber before the settlement of Europeans.

As regards the southern area it has been necessary, owing to the scale of the map, to give a shading indicative of the average density; but actually, as in other parts of Nyasaland, the inhabitants tend to gather along the rivers and other places where soil and water conditions are favorable; elsewhere only a very sparse population exists. For example, the higher altitudes of Chongoni Mountain, which rises to a height of 8000 feet, are quite uninhabited, whereas the well watered country immediately around its foot is far more densely populated than are the neighboring areas. Much of the land to the east is too mountainous and rocky for habitation, but it is of importance in augmenting the water resources of the adjacent areas; elsewhere, however, particularly about Lilongwe and westwards along the Fort Manning road, there are wide sparsely populated areas that include land well known to be of great agricultural value, especially for the growing of tobacco. The principal cause of this dearth of population is scarcity of water, but there appears but little doubt that much of the country could be adequately watered at moderate cost.

The Lakes and Lake Plains of Southern Nyasaland

A dense population is aligned around Lake Pamalombe, especially on the western side. This lake, however, is liable to great fluctuations of level; for example, it now extends over fully a hundred square miles, but three years ago it was completely dry. As the waters were receding year by year, the native rice and maize gardens were established farther and farther from the old lake shore; then when the lake rapidly rose again, owing to the erosion of a barrier in the bed of the Shire at the point where it enters the lake, all these gardens were destroyed and a local famine ensued.

Lake Chilwa and Lake Chiuta differ from the other lakes in

that their margins are almost entirely unpopulated; this is due partly to fluctuations of level and partly to the nature of the ground, which is locally either very sandy or very clayey and unsuited to the growing of the ordinary food crops; moreover, the waters of Lake Chilwa at least are slightly brackish. Nevertheless, where relatively high ground exists near the lakes, as along the low east and west ridge that runs between them, native villages tend to become established, largely because of an important trade in dried fish which is sold on the Shire Highlands. This is true of Chilwa Island also, which has a population density of a little more than 100; the island is high and rocky, with a narrow plain around the margin; and on it the people have the advantages of dry land on which to build their huts and make their gardens, timber and fresh water from the mountain, and abundant fish from the lake.

Southwest of Lake Chilwa, on the low watershed between the Palombe and Tuchila Rivers, there is a large area subject to inundation. Much good agricultural land lies along the belt within which the gentle slopes of the Shire Highlands merge into the almost level plain; this land is considered of great promise for the growing of bright tobacco; but unfortunately much of it is waterless, particularly towards the end of the dry season when water is required for tobacco nurseries.

The Shire Valley Plains

The Shire valley plains, apart from the river and lake shores and the area south of Port Herald, are but sparsely populated. In an earlier account of the Shire valley[6] it has been shown that the soils and subsoils of the Shire plains fall into two well defined classes, according as they occur on the alluvial areas or on the gently undulating rocky areas, and a map was published showing the distribution of these two classes. The upper Shire between Fort Johnston and Matope and the lower Shire between Chikwawa and Port Herald traverse broad alluvial plains, whereas the middle Shire between Matope and Chikwawa traverses wide rocky plains on which the soils, when present, are almost invariably thin and stony. The Bwanje valley is similar to the upper Shire valley as regards soils and general structure.

The dry, sterile, and stony areas are of no appreciable economic use, except here and there where small patches of alluvium exist near the river banks and it is not surprising that they are very nearly uninhabited. The dearth of population on the broad interfluvial areas of the alluvial plains is explained by the absence of adequate supplies of water. The amazing fertility of the alluvium when water is available is exemplified by the lower Shire area below Port Herald, which

[6] Dixey, The Physiography of the Shire Valley.

is the most densely populated part of the whole Protectorate; over an area of 125 square miles the average population density exceeds 300, so that here the soil is probably carrying the maximum number of inhabitants. This area, however, lies between the Shire on the one side and the Port Herald Hills on the other, and at the foot of the hills a number of small streams occur; moreover, the area is low-lying, and in addition it is traversed by the Ndindi Marsh, in which water is available all through the year.

It is practically certain that all the broad alluvial lands of the Shire and the Bwanje valley could be adequately watered by means of boreholes of moderate depth, probably about 100 feet on the average. Moreover, it has been demonstrated that in many places water is available within reach of excavated wells; and amongst the foothills that frequently limit the alluvium on either side numerous good sites exist for the construction of dams for irrigation purposes.

The lower Shire area is now the most important center of native cotton growing, but the inadequacy of the water supply sets a limit to the expansion of the industry.

The Scarps and Plateaus

In general the scarps separating the Shire valley plains from the neighboring plateaus are but poorly populated, as in the case of the scarps of northern Nyasaland; this is chiefly because they are usually very steep and sometimes even precipitous and frequently also dry. In the two areas, however, in which they are of moderate slope the case is different; in the Ncheu area the scarp falls to the plain partly by several broad steps and partly uneven slopes; and here, where good residual soils and fair water supplies exist, the population density is 112; in the Blantyre-Matope area, where moderate slopes again are found, the population density is about 60; and along the foot of the slope, where there are better soil and more water, it rises to 85. The scarps forming the eastern and southern limits of Cholo District are also fairly well populated.

The low scarps of the Chilipa plateau separating the upper Shire from the Bwanje valley are unpopulated; but on the little plateau itself, about the feet of Pirolongwe, there is a good cluster of villages.

While the lofty Mlanje plateau[7] is uninhabited, the lower plateaus of southern Nyasaland, including Namwera, part of the Ncheu area, and the Shire Highlands, comprise some of the more densely populated areas in the Protectorate. The dense population of the Ncheu area lies mainly at 2500 to 3500 feet; but along the slopes of the Kirk range and northwards towards Mlangeni, apart from places of European occupation, it locally attains to 4000 feet, or even, in

[7] See F. Dixey: The Mlanje Mountains of Nyasaland, *Geogr. Rev.*, Vol. 17, 1927, pp. 611–626.

the more sheltered places, to 4500 feet. The dense population of the Chiradzulu-Blantyre area lies mainly between 2500 and 3000 feet, although locally approaching 3500 feet.

The denser native populations are very largely due to the presence of the European towns and estates, which have arisen essentially because of the generally good soil and water conditions, as well as the favorable climate. In some of these areas, however, particularly in the Chiradzulu and Blantyre districts, the native population is highly congested, so that in a number of places the land is supporting its maximum number of inhabitants. Conditions have been rendered much more difficult in certain areas owing to the ruthless deforestation that has taken place in recent years, and this applies particularly to Chiradzulu District.

Relief of congestion in the Blantyre and Chiradzulu areas is made almost impossible by the absence of water in neighboring areas that are otherwise suitable for native settlement; a little has been done by excavating wells, but the question urgently requires more active measures than have been possible in the past.

The question of water supply is a very serious one also for the European towns of Blantyre and Limbe; the most hopeful measures rest in the demarcation of suitable collecting grounds combined with the establishment of local forest reserves.

SOME POPULATION GRADIENTS IN THE UNITED STATES

A. B. Wolfe

Ohio State University

A JOURNEY of a hundred miles in any direction almost anywhere in the country—even in the corn belt—will reveal to the traveler, if he has eyes, noteworthy differences in population density, differences due fundamentally, if not wholly, to variations in topography, fertility, and climate. Usually the transition from high to low density of population is gradual, but it is frequently sudden.

One of the sharpest density gradients in the world, and one most obviously caused by topography, exists within the metropolitan area of New York City, where the densely populated strip west of the Hudson—the highlands and lowland covered by Jersey City, Hoboken, Weehawken, and smaller towns to the north—lies immediately contiguous, with no transition zone, to the uninhabited tidal marshes of the Hackensack meadows. This illustration, however, is somewhat obvious. Similar sharp transitions may be noted around other cities, especially those on low-lying coasts.

An Example from Texas

A better example, because it involves rural as well as urban population, is to be found in Texas. From Waco, south through Austin, runs a fairly sharp and continuous line of faults, producing what is known in general as the Balcones Escarpment. It separates the fertile Black Waxy Prairies on the east from the Edwards Plateau on the west and marks in part of its course an extremely sharp population gradient.

East of the Balcones Escarpment lies one of the greatest cotton producing districts in the country, if not in the world—a region of deep black soil, prairies that billow in broad folds a mile or two from crest to crest, fine towns, good roads, and a population of relatively high density. Its productivity and wealth are indicated by a row of thriving towns and cities, Fort Worth, Dallas, Waxahachie, Waco, Temple, Georgetown, Austin, San Marcos, New Braunfels, and San Antonio.

West of the Escarpment rises the Plateau, much dissected in its eastern part and consisting of limestone hills and ridges separated

by the dry beds of rocky streams, box canyons, and narrow valleys in which there is only an occasional old flood plain of alluvial soil. The hills have either a very thin and rocky soil or none at all and are covered with a growth of scrubby juniper, known locally as cedar, Spanish oak, and miscellaneous chaparral. There is a rapid run-off of rainfall, and during the summer what soil there is is burnt to dry powder. Along the few streams farming is here and there possible, and pecan growing will doubtless develop into a profitable industry locally, but in the main the bulk of this eastern and rougher part of the Edwards Plateau is wholly unfit for farming. For many miles west of Austin the sparse population, consisting mainly of poor whites, known locally as "hill billies," who eke out a slender existence by hunting, charcoal burning, and hauling firewood, attests the poverty of the soil and the unfavorable topography. Within three or four miles of the capital of Texas, a city which unofficially now lays claim to a population of 50,000, one can enter country which is to all intents uninhabited. A few years ago a mountain lion was shot within sixteen miles of the Capitol dome, and deer are sometimes met with even closer. Yet the density of rural population eastward from the base of the Balcones Escarpment rivals that of Illinois.

The sharpest contrast, both in topography and in population density, between the Black Waxy Prairie and the Plateau, is to be found between Round Rock and New Braunfels. Between Round Rock and Austin the transition is made in a few miles, in some places scarcely a mile, from the densely populated farming land to the practically unpopulated hill country. The difference in elevation, while abrupt, is not great, the Balcones Escarpment being marked on the landscape by a line of low-lying hills. The prairie country in the Austin quadrangle averages perhaps 600 feet in elevation, while the neighboring plateau region ranges from 700 to 1200 feet, rising steadily toward the northwest. There is not an abrupt difference in rainfall, although in this part of Texas the isohyetal lines are fairly close together and run almost due north and south.[1] The line of 30 inches of average annual rainfall follows roughly the 99th meridian, and on a population map of Texas a noticeable density gradient roughly follows the same meridian. The abrupt difference in density between the hill region and the prairie is not due to difference in precipitation, however, but to soil and topography, and these in turn to geological formation.

Recent decades have demonstrated that cotton can be grown profitably on the plains of western Texas, even in parts of the Llano Estacado, and far up in the Panhandle, where the winter temperature may touch zero and where the average annual rainfall is but little

[1] Atlas of American Agriculture, Part II, Section A, Precipitation and Humidity, U. S. Dept. of Agriculture, 1922, pp. 6, 7.

over twenty inches.[2] But between the Black Waxy Prairie of central Texas and these far western high plains lies the immense region of rough and broken country comprised by the Edwards Plateau, the Central Mineral Region, or Granitic Hills, and parts of the Grand Prairie and the Western Cross Timbers. In this rough country neither soil nor topography is suitable for much else than goat and cattle ranching.[3] The lower capacity of the rough country, as compared with the Black Waxy Prairie, to support population is indi-

TABLE I—POPULATION DENSITIES OF CERTAIN TEXAN COUNTIES

PLATEAU			PLATEAU-PRAIRIE			PRAIRIE		
	TOTAL	RURAL*		TOTAL	RURAL		TOTAL	RURAL
San Saba	9.0	9.0	Bell	42.9	28.0	Falls	48.6	42.8
Lampasas	11.9	11.9	Williamson	38.0	30.2	Milam	39.7	35.3
Burnet	9.8	9.8	Travis	57.4	22.6	Lee	24.9	24.9
Llano	5.5	5.5	Hays	25.6	18.3	Bastrop	30.7	27.0
Gillespie	9.0	9.0	Comal	15.8	9.4	Caldwell	49.2	41.9
Blanco	5.4	5.4	Bexar	160.0	32.2	Gaudalupe	39.4	34.2
Kendall	8.0	8.0				Wilson	21.3	21.3
Medina	8.6	.8.6				Fayette	31.0	31.0
						Gonzales	27.9	24.8
						Lavaca	30.5	26.4
						De Witt	31.8	25.0

*Excludes the population of towns of 2500 and over.

cated in Table I and the map, Figure 1. On a small scale it is shown on the dot map of the rural population density of the United States appearing in the Atlas of American Agriculture.[4]

The population gradient between the Black Waxy Prairie and the timbered red soil region of eastern Texas is not so pronounced or abrupt but it is none the less noteworthy. Here again soil fertility is the main factor, though other conditions enter in to counterbalance the more copious rainfall of the eastern part of the state. The eastern topography is flatter and lower. The Trinity, Brazos, and other rivers have broad flood plains; the local drainage is poor; and there are many swamps and sloughs. This part of Texas, like great areas in Arkansas and Louisiana, is afflicted with malaria. It is possible, also, that the relatively less dense population of this eastern part of the state has

[2] Atlas of American Agriculture, Part V, Section A, Cotton, U. S. Dept. of Agriculture, 1918, pp. 8–10. Since 1910, cotton production has been extended still further than shown in this publication. Cf. Statistical Atlas of the United States, 1924, p. 410.

[3] Atlas of American Agriculture, Part V, Section A, p. 8.

Bonney Youngblood and A. B. Cox: An Economic Study of a Typical Ranching Area on the Edwards Plateau of Texas, *Texas Agric. Exper. Sta. Bull. No. 297*, 1922.

[4] Part IX, Section I, Rural Population, 1919, p. 4 (distribution of the rural population in 1910). Cf. Statistical Atlas of the United States, 1924, pp. 139, 140 (density in 1920, but not a dot map).

historical causation in the fact that it was easier for the settler to go on to the open prairies than to stop here and clear the timber.[5] Other sharp density gradients in Texas are to be found in the lower Rio

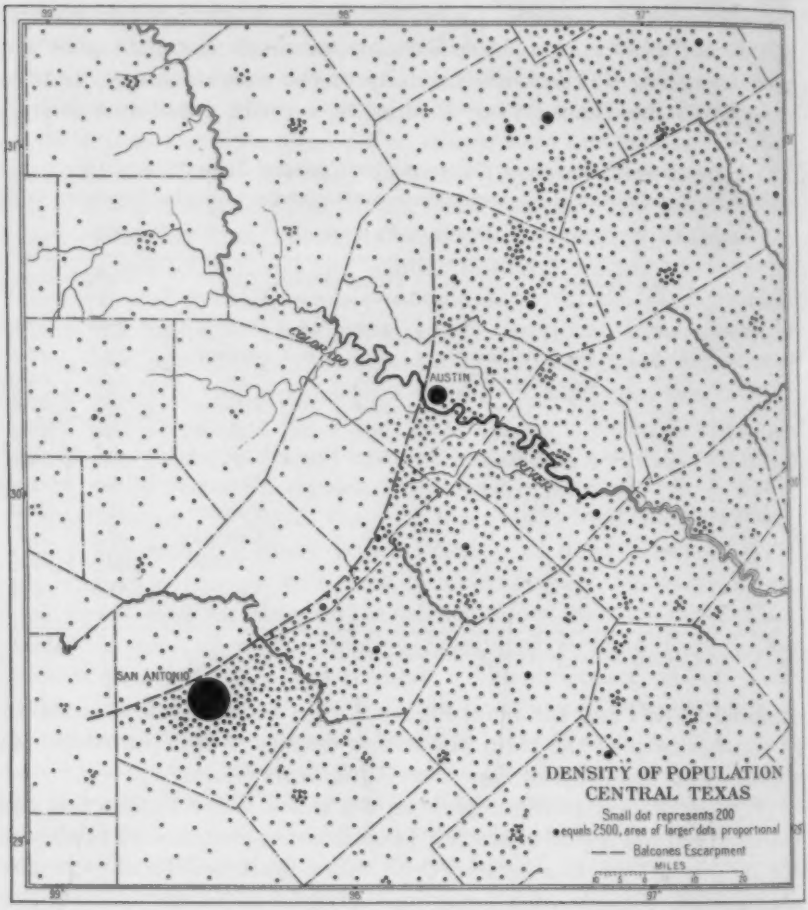


FIG. 1—Map showing contrasts in population density between prairie and plateau counties in Central Texas. Scale approximately 1:2,500,000.

Grande Valley, along the Pecos, and about El Paso. The first two cases are due to irrigation, and the last is due to the presence of an urban center plus irrigation.

It would be interesting to speculate to what extent these sharp gradients will be affected by future population movements. Between 1910 and 1920, census figures indicate high percentages of increase in the south and along the Gulf Coast, in eastern Texas, in the Panhandle, and on the plains south of the Panhandle; while the whole central

[5] Cf. F. L. Olmsted: A Journey Through Texas, New York, 1857.

region, including the Edwards Plateau, the Grand Prairie, and the Black Waxy Prairie itself, suffered heavy losses, especially in rural population.[6] It is safe, however, to predict that the Balcones Es-

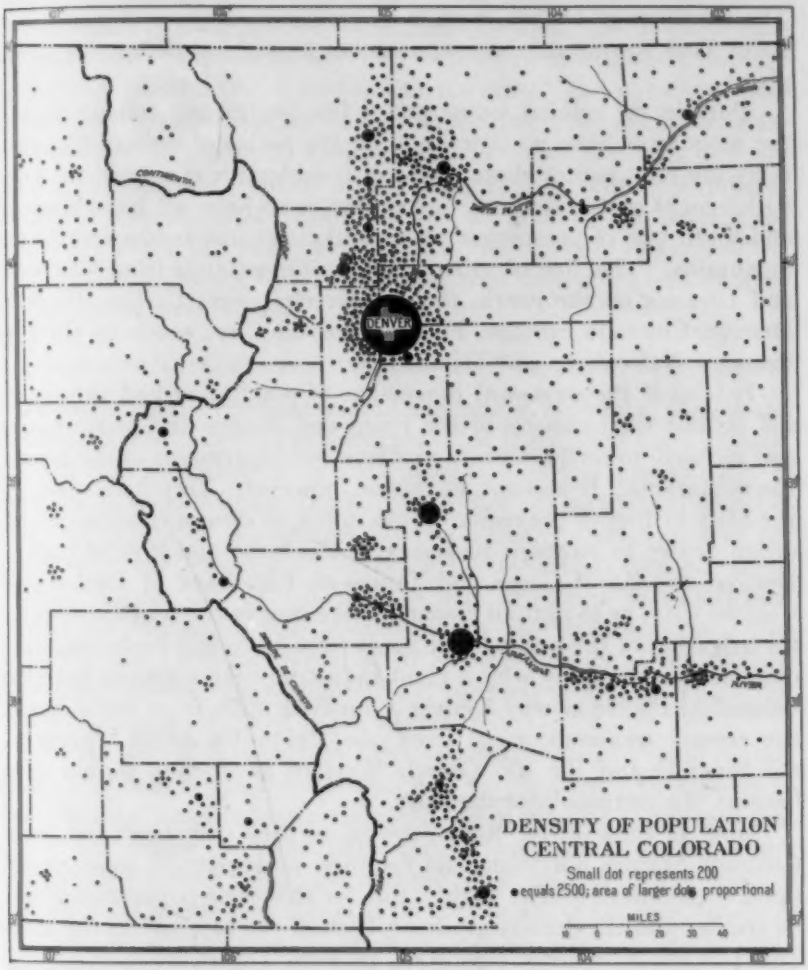


FIG. 2—Map showing contrasts in population density in the Front Range region of Colorado. Scale 1:3,750,000.

carpment will continue for an indefinite time to mark a very steep population gradient.

THE FRONT RANGE REGION OF COLORADO

In Colorado are cases of sharp contrast due to irrigation, as along the Arkansas and South Platte rivers (Fig. 2). Other cases are due

[6] Statistical Atlas of the United States, 1924, pp. 81, 82.

to urban centers and to topography. The sharpest gradient in Colorado, and one of the sharpest in the whole country, is that between the thickly populated irrigated districts north of Denver immediately east of the Front Range and the mountain region to the west (Fig. 2). The Continental Divide, with a magnificent rampart of peaks from Estes Park southward, here approaches to within a few miles of the plains.

Outside the mining towns and a few health and tourist resorts, the mountains have no cities, and on the plains of eastern Colorado there are only two or three towns of considerable size until we come within sight of the Rockies. As in Texas, so here, we have a north-and-south row of prosperous towns and cities just to the east of the mountains. This line of urban communities extends from Cheyenne and Laramie on the north, through Greeley, Fort Collins, Boulder, Denver, Colorado Springs, Pueblo, Canyon City, south to the coal towns of Walsenburg and Trinidad.

It is as if the westward movement of population had thrown itself against the ramparts of the Front and Sangre de Christo ranges and recoiled, to settle in chance valleys and depressions at the base of the mountains. It was not all chance, however. Very little study of the early history of the region would suffice to show a relation of each urban center to strategic passes—e. g. Berthoud and Rollins back of Denver, the Royal Gorge and Tennessee Pass back of Pueblo and Canyon City, or to natural resources, like coal in the south and water for irrigation in the north. Yet apart from historical beginnings it is difficult to see exactly why a great industrial center should have developed at Pueblo or why Denver a hundred miles from the routes of the central transcontinental lines, the Union Pacific at Cheyenne, the Santa Fe and the Rio Grande Western at Pueblo, should have become the metropolis of the state.

Most of these Front Range towns, as they may be called, from Colorado Springs north, depend for their prosperity to some extent upon the summer tourist trade. But for this their population would be smaller and the density gradient, both to the east and to the west, would be less pronounced than it is. As long as there are railroads and automobiles and people with money to travel, the climate and natural beauty of this region will be assets tending to maintain the present gradient. The remarkable density of population of the plains immediately east of the mountains and north of Denver, in Larimer and Boulder counties and the western part of Weld and Adams counties, however, is due to the fact that this is one of the most successful irrigation districts in the country, with a high productivity in fruit, vegetables, and sugar beets. The agglomeration in eastern Fremont county, where the Arkansas River emerges from the Royal Gorge, is due to similar causes.

The Lower Peninsula of Michigan

In Michigan an interesting population gradient unfolds between the southern and northern halves of the Lower Peninsula. In the south, diversified farming, prosperous towns, dense population; in the north, barren wastes of sand covered with scrubby second growth where once the great white pine forests stood—a region now of extremely dubious agricultural possibilities, a problem to the state,[7] and not likely soon to have any considerable permanent population, but capable of yielding considerable profits to speculative land companies who now are offering swampy lake frontage at fifty dollars a front foot. The present density of this part of Michigan is in fact not greater than parts of the Edwards Plateau in Texas. Roscommon County, only 150 miles from Detroit, has a density (3.1), which matches that of regions of little promise in far west Texas.

Contrasts in Southern Illinois and Eastern Tennessee

In Illinois and Tennessee we find unexpected reversal of the general rule that plains have high density, provided there is adequate rainfall, and the hills and mountains a low density. In the hilly country of southern Illinois, Williamson and Saline counties have rural densities of about 75 and 85 per square mile respectively—comparable to the densities of the counties tributary to the industrial districts about Chicago, Peoria, and St. Louis. The high density of these southern Illinois hill counties is due to coal mining and fruit growing. The density of the total population of Jo Daviess County in the extreme northwest—also a rough country and formerly a mining region but now no longer so—is only 35 per square mile.

In the mountains of eastern Tennessee,[8] where only a small portion of the land is in crops, there is a region of high density juxtaposed to one of low. The high density here must be attributed to the fact that this is the region of "our contemporary ancestors," among whom contentment with a "hog and hominy" standard of living, coupled with an Elizabethan conception of the proper size of families, conduces to unlimited procreation. The same low standard of culture and absence of family limitation obtain among the "hill-billy" part of the population of the Edwards Plateau in Texas, but they have neither the soil nor the rainfall to support the density that obtains in eastern Tennessee. Families may be just as large, but they are few and far between.

A More Refined Study in Texas

These are but samples of the interesting phenomenon of the population density gradient. So far as the present writer knows, little at-

[7] Cf. M. M. McCool and J. O. Veatch: Sandy Soils of Southern Peninsula of Michigan, *Mich. Agric. Coll. Exper. Sta. Special Bull. No. 128*, January, 1924.

[8] Atlas of American Agriculture, Part IX, Section I, Rural Population, p. 4.

tempt has been made to study it in detail. Unless it be from personal observation, which can usually give no basis for accurate statistical comparison, we know little about local, but often very significant, density gradients in this country. The maps in the Census Bureau's Statistical Atlas for 1920 (Pls. 69, 72–118), showing population density by counties, have two shortcomings. The numerical grouping of densities (less than 2, 2 to 6, 6 to 18, 18 to 45, 45 to 90, and 90 and over, per square mile) is too rough, and the density is represented by a uniform tint for the whole county, whatever the actuality. An adequate study of local density gradients requires not only the requisite census data of population but also topographical and political maps of sufficient detail and on a sufficiently large scale. In most cases the topographical sheets of the United States Geological Survey should be adequate, if they happen to exist for the area being studied. A serious difficulty, however, is encountered in the fact that political administrative units, by which census population is tabulated, do not always correspond to topographical features. Thus the Balcones Escarpment in Texas cuts across the middle of several counties (Fig. 1). If, therefore, we wish to map population densities above and below (west and east) of the Escarpment with meticulous accuracy, we must have statistics by units smaller than counties.

Volume I of the 1920 Census of population gives county populations by townships, boroughs, justice precincts, and other minor civil divisions, the unit and title varying with the state. The standard Federal land survey township is six miles square; but in some states, e.g. in Texas and the Atlantic states, there is no standard shape or size. We have nothing to show the areas or locations of the numbered civil districts in Tennessee counties, for instance, or the justice precincts in Texas. For a dot map of population we do not need the areas of these local divisions, but we must know their approximate boundaries. Although the Census tabulates population by local civil divisions within the counties, the Census Bureau has on file no information with regard to the location of these divisions. Despite this curious lack of local geographical information on the part of the Census Bureau, one could, with a sufficiently large library of local political maps, make an accurate study of local population distribution—provided the maps showed the location of the minor civil divisions, within the county, by which the Census data are tabulated and provided no changes in the boundaries of these divisions had been made between the Census date and the map date.

Unless the investigator is on the ground of the region being studied he will inevitably encounter great difficulty in obtaining the necessary information as to the location of the minor civil districts. For this information he will have to appeal to county officials, and it will often be given in a form difficult to utilize.

Returning to our Texas illustration, we have the following Census data for the total population of Travis County (1920) by justice precincts:

Precinct 1	1,874	Precinct 5 including part of Austin City	3,330
Precinct 2 including Manor town	5,916	Precinct 6 including part of Austin City	7,570
Precinct 3 including part of Austin City	34,579	Precinct 7	505
Precinct 4	3,221	Precinct 8	621

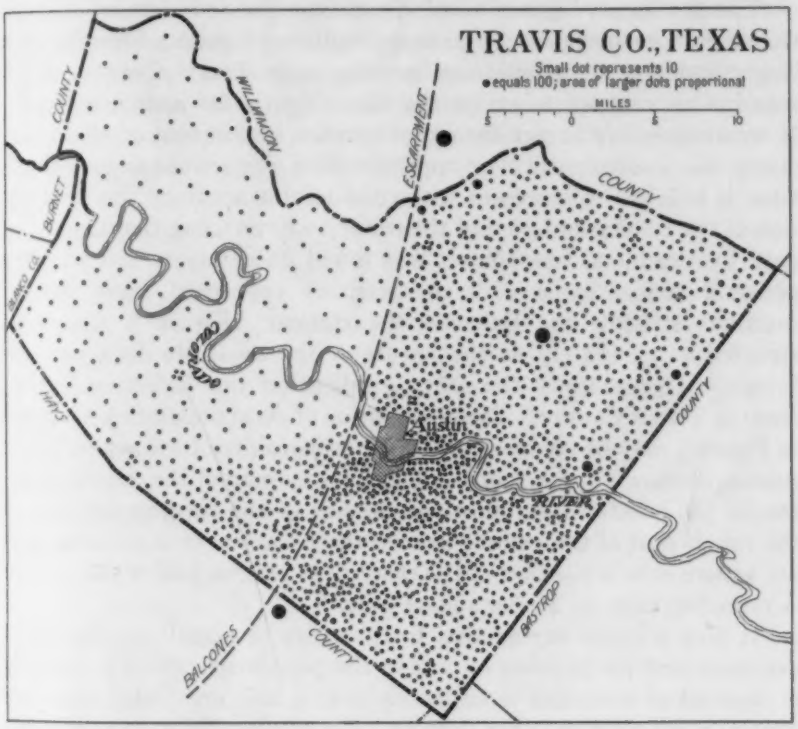


FIG. 3—Map of Travis County, Texas, showing effect of Balcones Escarpment on distribution of population. Compare Figure 1.

Each of these justice precincts consists of a number of election precincts, 58 in all, the boundaries of which are minutely described in a sixteen-page pamphlet issued by the County Commissioners, and defined by reference to ancient land grants (not given on any ordinary civil map), local roads, railroads, creeks, etc. It is practically impossible for a person who is not actually on the ground accurately to locate these precincts. The following, from the Travis County Commissioners' Court, "Order Re-establishing the Several Election Precincts," 1924, is one of the simpler and plainer of the descriptions:

Beginning on the Travis and Bastrop Counties' line at a point from which the northeast corner of the Wm. Hines League bears South 60° E.; then north to Hines' League corner and continuing in the same direction with the north line of said Hines' League, and with the road to the northeast corner of the Kimbro League; thence northwest to the Cele and Lund road; thence westwardly to the Manda and Manor road; thence south to the Kimbro and Manor road and to the southwest corner of Mrs. Schieffer's farm; thence east to another Kimbro and Manor road; thence southwardly with the said road to the Houston and Texas Central Railroad; thence with said railroad to the line of the counties of Bastrop and Travis, and thence northwardly with said county line to the place of beginning.

The dot maps, Figures 1 and 2, were constructed without attempt to use the Census figures by justice precincts. Figure 3, showing on a larger scale the distribution of population in Travis County, is the result of an attempt to utilize the above figures for justice precincts. It was impossible to get the exact location and extent of these precincts, but a sufficiently close approximation was arrived at to indicate what is believed to represent with considerable accuracy the distribution of the rural population of the county. Even using the population data by precincts, however, it was found necessary to fall back on personal acquaintance with the territory concerned, since certain precincts straddle the Balcones Escarpment. Figure 3, thus constructed as accurately as the nature of the available data permits, brings out graphically the sharp gradient at the Balcones Escarpment in Travis County. The distribution of rural population as shown in Figure 3 may be compared with the topography of the region about Austin, as shown in the topographical survey map of the Austin quadrangle. It is safe to say that the density of the rural population of the rough part of the county west of the Escarpment is not over 2.25 per square mile, while that of the eastern, or prairie, half of the county is probably close to 40 per square mile.

It goes without saying that for purposes of visual comparison of densities, and for locating on a map the population where it actually is (instead of spreading it uniformly over a unit area), dot maps are generally superior to other devices. Geographically a most instructive map would be one with contours in one color and population dots in another, both printed legibly on the same sheet. As Vidal de la Blache says:

If detailed statistics of population are compared with equally detailed maps, such as are available in almost all the principal countries of the world today, it is possible, by analysis, to find a connection between human groups and physical conditions. Here we touch upon one of the basic problems of human population. For the existence of a dense population—a large group of human beings living together in the smallest space consistent with certainty of a livelihood for the entire group—means, if one stops to think of it, a victory which can only be won under rare and unusual circumstances.[9]

[9] Paul Vidal de la Blache: Principles of Human Geography, transl. by M. T. Bingham, New York, 1926, pp. 14, 15.

These circumstances—of climate, topography, and fertility—have not been so rare and unusual in the United States as in some other parts of the world; but it is clear, however unable the population optimists may be to understand the fact, that further expansion of population into districts of less favorable topography and humidity can be made only as a result of pressure, of dynamic cultural change, improvement of technique in the extractive industries for instance, and with some diminution, if expansion goes too far, of certainty of livelihood at the present standard of living.

The examples of population gradients here given, and their relation to the basic topography, suggest a fertile field of coöperative research among American geographers, agricultural experts, and students of population. Ultimately may we not look forward to a population-and-resources survey comparable in detail and scope to the Geological Survey?

IRRIGATION SYSTEMS OF PERSIA

Commodore B. Fisher

American Boys' School, Hamadan, Persia

IN this tract of country there is no water appearing on the surface, though there are many subterranean channels which have well-shafts sunk to them, at spots in the desert unknown to persons unacquainted with the district. A true account of these channels has been preserved among the natives to the effect that, during the Persian ascendency, they granted the enjoyment of the profits of the land to the inhabitants of some of the waterless districts for five generations, on condition of their bringing fresh water in; and that, there being many large streams flowing down Mount Taurus, these people at infinite toil and expense constructed these underground channels.

Thus Polybius described the problem of water supply in Persia, and so it is today.[1] *Kanats*, as the underground channels are known, are characteristic signs of a Persian village. Leading down from the mountains to the numerous villages scattered about the interior basins are long lines of dug wells, rimmed about by the dirt that has been removed and resembling in appearance the shell craters of the battle fields of northern France. The wells are about twenty yards apart, and most of them are rimmed around with earth and rock to a height of three or four feet. The well itself, sometimes as deep as one hundred feet, is neatly walled up and frequently covered with large flagstones and loose dirt. These are the only outward signs of the tediously constructed underground tunnels that collect life-giving water for a dry and thirsty land.

The dryness of the Iranian plateau is well shown in Professor de Martonne's maps of aridity and interior-basin drainage in the July, 1927, number of the *Geographical Review*, to which reference should be made. The great part of the plateau has only interior drainage. Winter snows on the lofty ranges give rise to turbid streams in the early spring, which dwindle away with the coming of summer. During the season when they are full some use is made of this water for irrigation. Hundreds of ditches have been constructed on the mountain sides to carry this surface water miles away in different directions. With only an eye for the lay of the land and the persistent use of crude hand-forged picks and shovels the mountaineer lays out the system on a trial and error basis. As the dry season advances most of the surface streams dry up, but deep underground seepage continues to supply

[1] The Histories of Polybius, translated from the text of F. Hultsch by Evelyn S. Shuckburgh, Bk. X, Ch. 28 (Vol. 2, p. 27). See also James Morier: A Second Journey through Persia, Armenia, and Asia Minor, to Constantinople Between the Years 1810 and 1816, London, 1818. Morier describes the construction of channels on pp. 163–164.

brackish water to the swampy oases on the basin floor. To bring this underground water to the surface and distribute it over the thirsty land that lies between mountain and swamp is the problem solved thus anciently by systems of underground channels. The method is widely used among the desert peoples of the Old World,[2] and it has been introduced into the New World.[3]

Construction of the Kanat

The construction of the *kanats* is usually a professional matter. The digger begins excavation on a gentle slope and gradually works underground. Aiming at some dry river bed or other depression, the tunnel, about two feet wide and four feet high, is extended on up toward the mountains. The bed is kept almost level, and stone and dirt are removed through the regular series of wells. Day after day with only the flickering light from a crude grease lamp the excavators crouch down in the mud and water under an unsupported ceiling dripping from overhead seepage. With an eye to detect water-bearing strata the master workman digs ahead while his helper fills his goat-skin buckets and drags them to the last well or opening. Here a third workman uses a large reel or windlass to draw the bucket to the top. The chief obstacles encountered are the great boulders that in times past have rolled down the mountain side and become embedded in the soil of the plain. They are overcome with characteristic patience. When they occur in the path of the tunnel it is easy to curve around them. When they are encountered in the middle of a well the boulder must be turned to one side. Another difficulty is presented by strata of soft dirt. Here stones must be lowered and the tunnel walled up on both sides and covered over with closely fitted flagstones.

As the work progresses and the tunnel passes deeper and deeper underground, water-bearing strata are reached. Here the course is changed to intercept the seepage; or, better still, laterals are dug out from the main tunnel. Then forward again with other branches, until a network of five miles or more, with as many as 500 wells, has been completed. The wells in reality are comparable to manholes in an underground conduit system, yet they may be used as real wells from which water is drawn from the tunnel stream.

Water for Domestic Purposes and Irrigation

The amount of water furnished by one of these *kanats*, varies with the amount of water supplied by natural seepage and with the skill with which the *kanat* has been fitted to the natural lay of the land. The

[2] Jean Brunhes: La géographie humaine, 3rd edit., Paris, 1925, Vol. 2, p. 599.

[3] Isaiah Bowman: Desert Trails of Atacama, *Amer. Geogr. Soc. Special Publ. No. 5*, New York, 1924, p. 20.

waste-covered mountain slopes act as a great reservoir, holding back the water that soaks in with every fall of rain and snow. Such seepage as this furnishes a country home with an ample water supply if only one well is dug. But a tunnel dug at the same depth will supply as much as thousands of wells dug side by side. These tunnels, for the most part privately owned, provide artificial streams large enough to turn an old-fashioned water mill.

The stream, as it emerges from its underground source, is usually led on down through the village to furnish drinking water for man and beast. It is also convenient for washing clothes, and the village butcher finds it to be a good place to wash his meat, as well as to dump his refuse. The energetic landlord may utilize the banks of the stream to grow trees for building purposes; and the stream itself may furnish him a fish supply. If he has an eye for beauty he may lay out by the stream long drives between tall poplars and willows, bordered with arbors of roses and lilac.

Having watered and cleansed the community, the water passes out beyond the village into the real irrigation ditches, usually raised above the level of the alluvial plain. These elevated grass-covered ditches render the use of modern agricultural machinery impracticable. The small plots they enclose are plowed up with a yoke of oxen and an iron-tipped forked stick. After breaking up the ground, three men use a very wide ridging spade which is pulled by ropes attached to either end. In this way a network of ridges is thrown up that hold the water in level patches on the ground. With this poor seed bed and practically no further cultivation excellent crops of wheat and barley, poppies, melons, and vegetables are grown. During the growing season the farmer's chief task becomes that of turning in the water. A few shovels of dirt change the course of the stream from ditch to ditch so that the water is spread out over the growing crops once every week or ten days. Methods of dry farming might well be introduced, but that would require more work. So the farmers are content to continue the old methods, which require little more than directing the flow of the water.

Problems of Ownership and Maintenance

Such systems as here described cost thousands of dollars to construct, even though the master workman receives only one dollar a day and his helpers less than half as much. The wells are a real obstruction to good cultivation, while irrigation directly over a tunnel causes an expensive cave-in; hence a thirty foot right of way is usually kept open as waste land above the entire *kanat* system. Then too the constant seepage into the *kanat* drains the surrounding ground and renders it less productive.

Because of the expense and the difficulty of coöperative effort on the part of small landowners, these irrigation systems are privately owned and tend to perpetuate the feudal system which is well organized in Persia today. A wealthy family can purchase an extensive tract of desert land, make a large investment in a water system, and attract hundreds of tenants who are eager to make their homes around the water supply. Under the need of water and the difficulty of securing it, these tenants are easily reduced to virtual slavery.

Once constructed, the *kanat* guarantees the prosperity of both overlord and peasants as long as it is kept in repair. The village will continue to increase in size and beauty till future generations come to accept their prosperity as a matter of course, giving little attention to the maintenance of the source of all their prosperity. Finally some scion of the ruling family is afflicted with the wanderlust, disposes of surplus carpets, grain, and flocks, and spends a season in Paris. At the same time the old *kanat* is fast falling into decay. The tillable ground ceases to bear fruit, the fields are caught up in the desert again, and the village drifts along more dead than alive. Finally, leaving a water supply hardly sufficient for the private gardens of the ruling family, the villagers move away, going to the city to pick up a precarious living or making a new start in life by joining themselves to other villages.

Systems in the Cities

The *kanat* systems of the larger cities have expanded with the city's growth. The lines of wells, each marking the route of one of the artificially constructed watercourses, reach out on the upper side of the city like the spokes of a wheel, bringing the water down into different sections. Considerable friction frequently arises in the competition for water, and constant vigilance is necessary. Secret laterals may be dug out from one main tunnel to undermine another *kanat* that provides a good water supply. Obstructions may be placed in the wells, and worse still are the pools which are constructed in private gardens through which the water flows as it nears the surface. Where the stream is within about ten feet of the surface, wealthy citizens may build their houses directly over it and excavate a large basement down to the level of the water. This vaulted room with its tiled floor and walls, pools for washing dishes, clothes, and fruits, and special place for bathing adds much to the value of the property. Delightfully cool retreats these are in which to rest from the blistering sun; but it is well not to look too closely at the gurgling stream lest its charm pass away. The water, clear as crystal, may now become murky with tea leaves from some neighbor's party. Then greasy water from the dinner dishes or suds from the family wash may follow in close succession. So, one ceases to relish the running spring water which

the host lifts proudly for his refreshment. Even the fruit, beautiful and good as it may be, loses some of its charm when lifted from a cooling bath in this priceless stream.

After running through a dozen or more of these vaulted basements the stream comes to light. It is then divided into *dongs*, or sixths, as is the Persian practice for the division of ownership in water or real estate. One yard may have water rights of one-half *dong* three times a week, more or less, as stated in the deed to the property.

Practically every courtyard has its open pool through which the surface stream flows as it passes through the city. When water is scarce it is a decided advantage to live at the head of the stream. Here the pool may be frequently emptied and then refilled with the water that should pass on to the neighbor's yard—a kind of "tax" that is collected for permitting the water to pass through one's property. Not uncommon are the more flagrant abuses of the gentleman's agreement that permits the water to arrive at some distant yard. It becomes necessary to employ a special guard to sit at the head of the stream. Yet, for a small consideration, he too may permit a "break" in the ditch which would drain off a third of the water that should arrive at the garden. If he is an expert a watchful guard may close the break before the owner appears or, if caught, may smooth it over with profuse apologies for his neglect and repeated assurance that it has just occurred.

When properly cared for, the partnership *kanats* which supply the cities with water are inspected and cleaned every fall. Yet group ownership frequently leads to neglect, because that which should have been everybody's business becomes nobody's business; and then a large assessment is necessary to make essential repairs. These more extensive repairs are usually opposed by some shareholders whose funds are low, but the law of the land favors the man who would keep the *kanat* in repair. After giving due notice of intention to make needed repairs, the partners may go ahead with the work and withhold water rights from defaulting partners until bills are paid.

With the introduction of modern methods into Persia we might expect the construction of large reservoirs to be fed by the *kanats* that flow into the city. From these reservoirs water mains could be laid out to the different parts of the city, thus assuring the people a purer supply. Water mains through the long tunnels would simplify the repairing of crumbling *kanat* walls but would not permit the seepage along the way. It will be many years before we discover a better way to collect the underground seepage and water a city. As the Roman aqueduct was suited to the hills and valleys of a country with numerous springs, so the *kanat* of the Persians fits the physical features of their dry interior basins.

TRANSPORTATION DEVELOPMENTS IN CENTRAL AFRICA

M. Warthin

THAT interior part of Central Africa comprising Katanga Province, Northern Rhodesia, and Nyasaland possesses in its natural resources a vast wealth whose development has scarcely begun. A mineralized belt containing tremendous tonnages of high grade copper ore lies on both sides of the Katanga-Northern Rhodesia boundary. The holdings of the Union Minière de Haut-Katanga, a Belgo-British concern, which include most of the known deposits in Katanga, consist of separate ore bodies scattered over an area approximately 200 miles long and 20 to 70 miles wide extending from Chilongo to Elisabethville. It seems "likely that Katanga is really the greatest copper field ever opened."[1] North of the Katanga copper zone lies a second mineralized area containing tin and gold. Katanga, moreover, possesses sufficient radium to supply the markets of the world and by agreement with Canada divides equally with that country in the annual production of cobalt. Across the border in Northern Rhodesia recent prospecting has given good results, and "it is now an accepted fact that a copper field of great significance exists along the Northern Border, extending at least 150 miles in a north-west and south-east direction and having a breadth of not less than 50 miles."[2] A healthful climate, timber suitable for most purposes, and potential water power encourage commercial development.[3] The labor situation is improving as an increasing number of natives become resident in the district. With the completion of the construction work on the railroads and at the mines a large number of natives will become available for productive labor. It is estimated that the substitution of coal for wood in some of the mines will release 4000 wood cutters.[4]

Exploitation of these minerals has been retarded in the past by the difficulties involved in transporting them to tidewater. Although the region lies within the watersheds of the Congo and Zambezi Rivers, communication is impeded by rapids, irregularity of flow, or shoals.[5] This remote area was finally opened to world markets through the medium of the railway. A line by way of Broken Hill and Elisabethville reached Bukama, head of navigation on the Congo, in 1918. The products of this interior region now reach the coast at several South African ports or at Beira in Mozambique. Freight for export can also be shipped by water from Bukama to Kabalo, by rail to Albertville, by ferry across Lake Tanganyika, and thence by rail to Dar es Salaam. In 1926, the Katanga Railway routed 64,500,000 kilograms of copper via Beira and 16,300,000 kilograms by Dar es Salaam.[6] Thus, although its markets are in western Europe this region is forced to a costly export via the east coast of Africa.

Two railroads destined to play important rôles in the development of Katanga and

[1] J. R. Finlay: Copper. *Foreign Affairs*, Vol. 4, 1925, pp. 123–133.

[2] Northern Rhodesia, Rept. for 1925–26, *British Colonial Repts. No. 1363*, p. 16.

[3] O. Letcher: Katanga and Its Mineral Development, *Engineering and Mining Journ.-Press*, Vol. 119, 1925, pp. 277–284: G. L. Walker: What is the Future for African Copper?, *Engineering and Mining Journ.*, Vol. 123, 1927, pp. 401–403.

[4] S. H. Ball: Belgian Congo Grows in Mining World, *Engineering and Mining Journ.*, Vol. 125, 1928, pp. 197–200.

[5] On the situation and physical character of the region and the relation to exploitation see Maurice Robert: Le Katanga Physique, Brussels, 1927.

[6] *Congo et Bull. Soc. Belge d'Études Colon.*, Vol. 1, 1927, pp. 679, 680.

Northern Rhodesia are nearing completion. The more important of these, popularly known as the Benguella Railway, will link the port of Lobito in Angola with Chilongo in Katanga. Begun in 1905, its progress has been impeded by the international aspects of the project, but this spring the Portuguese section of the line will be opened officially. Recent rapid construction has been made possible by an agreement between the Belgian and Portuguese authorities arrived at in the summer of 1927. By the terms of this convention, Portugal engages (1) to equip the port of Lobito so that it may handle its traffic efficiently and (2) to put freight of Belgian origin on a

FIG. 1—Sketch map to show the recent railroad developments in Central Africa. The straightening of the Angola-Katanga frontier south of Dilolo is also shown. Scale approximately 1:37,500,000.

plane of equality with that of Portugal. In return Belgium undertakes to complete the railway from the Angola boundary to the Katanga Railway at Chilongo within five years after the arrival of railhead at the border. As the route is already surveyed and the material ordered, construction on the Belgian section should proceed apace. An exchange of territory was also agreed on. Belgium cedes to Portugal the district known as the Dilolo Boot, comprising 3500 square kilometers (see Fig. 1). In exchange Belgium obtains three square kilometers in the vicinity of Matadi and an understanding as to the utilization of the waters of the M'Pozo River. The unequal size of the territories exchanged is offset by the fact that the smaller area is vital in the reconstruction of the railway between Matadi and Leopoldville. The addition of the three square kilometers means a saving of a year's time and 12,000,000 francs.[7]

The great importance of the Benguella Railway lies in the fact that it provides, for Katanga and Northern Rhodesia, a direct all-rail route to tidewater several hundred kilometers shorter than that by Dar es Salaam or Beira. Distances from Elisabethville to the sea including transhipments are estimated thus: to Lobito, 2179 kilometers; to Matadi, 2609 kilometers; to Dar es Salaam, 2670 kilometers (4 transhipments); to Beira, 2765 kilometers (2 transhipments). Construction of the Kafue-Sinoia cut-off would, however, reduce the Beira route to 1806 kilometers.[8]

Lobito, in addition to being an excellent natural harbor, is located on the west

[7] *L'Afrique Française*, November, 1927, pp. 470–472.
[8] *Congo et Bull. Soc. Belge*, Vol. 1, 1927, p. 642.

coast of Africa thus shortening the trip to the European markets and avoiding the Suez Canal tolls. Since the line generally follows a watershed route it will be free of many of the "rainy season" troubles of its competitors. As the track is of standard South African gauge (3′ 6″), continuous rail travel will be possible between the Cape and Lobito. Although connection with the Katanga Railway will result in a great increase in its traffic, it must not be assumed that the Benguella Railway is without other resources. In the wake of the railroad's slow progress across Angola, an important agricultural development has grown up within 50 miles of each side of the track. This is significant for, although this railway will long remain the best route between Katanga and Europe, a competing all-Belgian line is already under construction. This route, approximately 400 kilometers longer than the Benguella Railway, comprises a continuation of the Katanga Railway from Bukama to Ilebo (Port Francqui) on the Kasai River, water transportation to Leopoldville, and railway to the port of Matadi. The last rail of the Bukama-Ilebo section was laid on February 13, 1928. Four 800-ton stern-wheelers are ready for the run between Ilebo and Leopoldville. Eventually it is hoped to link Ilebo and Leopoldville by rail, and, as the earthworks on the rebuilt section between Matadi and Leopoldville are so constructed that relaying the track will serve to convert it to the standard South African gauge, an unbroken journey may then be made from the Cape to the mouth of the Congo.[9]

The agricultural districts of eastern Northern Rhodesia and Nyasaland are not aided by these two new railroad enterprises. The sole railroad serving these regions runs only as far north as Blantyre, and its efficiency is seriously reduced by the lack of a bridge at the Zambezi crossing.[10] Little is known of Nyasaland's mineral resources, although recently attention has been called to the coal of the Lower Shire and the bauxite of the Mlanje Mountains.[11] Much of Nyasaland and eastern Northern Rhodesia is suitable for diversified agriculture; but in general cotton, tobacco, and tea, grown under the plantation system, are alone of sufficient value to bear exportation. The Katanga mining communities are dependent on the country to the south for their food supply, and in consequence a small district along the railroad in Northern Rhodesia is given a local market for produce that could not stand the charges of a longer haul. Maize is here handled by a coöperative society having a large contract with the mines. Cattle to the value of £46,000 were shipped to the Belgian Congo from Northern Rhodesia in 1926.[12] Native agriculture is largely confined to crops for local consumption and in order to obtain ready cash large numbers of natives are forced to seek employment in the mines or in the agricultural regions to the south. Such migrations will continue until native-grown crops can enter the export field. Settlement has been retarded. Of 1113 electors in the last voters list of Northern Rhodesia, 901 live in the railway zone and 105 in the Fort Jameson district, an important center of tobacco culture connected with Broken Hill by a motor road.

A bridge across the Zambezi at Sena will relieve the transportation situation in Nyasaland. If the coal deposits at Tete and on the lower Shire can be used at Beira for bunker coal, thus providing a bulky immediate source of traffic over the bridge, most of the objections to the cost of the project will be removed. Eastern Northern Rhodesia is even more isolated. Road connections with the railway to the west and with Lake Nyasa to the east are under construction, and the country would share the benefits of the various improvements proposed on the lines to Beira, including construction of the suggested Kafue-Sinoia cut-off. Eventually the best outlet would seem to be by Dar es Salaam via the proposed line from Dodoma to Fife.[13]

[9] *Ibid.*, pp. 630–648.

[10] *Geogr. Rev.*, Vol. 16, 1926, p. 501; *Rev. Econ. Internatl.*, Vol. 19, 1927, p. 81.

[11] See F. Dixey: The Mlanje Mountains of Nyasaland, *Geogr. Rev.*, Vol. 17, 1927, pp. 611–626.

[12] Northern Rhodesia, Rept. for 1925–26, *British Colonial Repts. No. 1363.*

[13] Imperial Shipping Committee: Rept. on the Harbour of Dar-es-Salaam, Tanganyika Territory, Cmd. 2917, 1927.

TWENTY-FOURTH ANNUAL MEETING OF THE ASSOCIATION OF AMERICAN GEOGRAPHERS

During December 28, 29, 30, and 31, 1927, the Association of American Geographers met in Nashville, Tenn., for its twenty-fourth annual meeting. Headquarters and accommodation for meetings were provided by the George Peabody College for Teachers. M. R. Campbell, of the U. S. Geological Survey and President of the Association, presided. The general belief that the attendance is affected when meetings are held away from the more densely settled centers was not realized; and the papers were delivered before groups averaging well in numbers those of the Philadelphia meetings of last December.

The Mississippi River Symposium

One of the important series of papers at the meeting was delivered before a joint session of the Association of American Geographers, Section E of the American Association for the Advancement of Science, and the American Meteorological Society, on problems relating to the Mississippi River. In this symposium, three papers discussed the floods, two dealt largely with forecasting, and three with other aspects of the river. H. C. Frankenfield, senior meteorologist of the U. S. Weather Bureau at Washington, with a paper on "Floods of the Mississippi from a Meteorological Standpoint," pointed out that the probability of a flood higher than that of 1927 was very remote, but he admitted that such an occurrence was possible. R. M. Williamson, of the Nashville Weather Bureau, spoke on "Floods on the Cumberland River and Lows That Produce Them," and W. E. Barron, of the Cairo Weather Bureau, on "The Gathering of the Waters and the Changing Régimes of the Mississippi and Ohio Rivers in the Cairo District."

I. M. Cline, forecaster in charge of the New Orleans center, in a paper on "Floods and Flood Forecasting in the Lower Mississippi" showed how the Weather Bureau were able to save many lives by predicting danger spots in the flood plain area and emphasized how, because of the lack of topographic maps of some of the flooded sections, relief was delayed. "The Flooding Rains of April in Relation to the Weather Map Situations," by N. H. Bangs and C. F. Brooks, was presented by Mr. Brooks, completing the second part of the series.

H. H. Bennett, in "Some Aspects of Soil Erosion in the Mississippi Basin," stressed the tragic waste of soil, aggregating in extreme cases forty tons of soil per acre per year. R. M. Brown presented a paper on "The Utilization of the Waters of the Mississippi River," in which the main points covered the domestic use, particularly the restraint of the waters from the home sites, and the use of the river for navigation. W. H. Haas closed the symposium, speaking on "Some Neglected Studies in the Mississippi Flood Problem."

The discussion of the papers was interesting and at times spirited. There was a tendency to break away somewhat from the themes of the papers to the engineering problem of flood control. This is not strange since, after all, what the engineer is going to do to bring any degree of security to the inhabitants of the flood plain is the crux of the problem.

A Field Trip and Papers on Field Work

The introduction of a field trip during the days of the meeting, a procedure inaugurated last year at Philadelphia, was continued; and the entire day of Friday

was devoted to an excursion to the Highland Rim and the Cumberland Plateau. This study was under the leadership of a committee consisting of A. E. Parkins, Chairman, K. C. McMurry, and Robert S. Platt. The general program of the Association may be carried on in any locality, and up to the present the only reason for changing the place of meeting has been based upon a rough attempt to average the mileage traveled by the members. With a continuation and expansion of the field discussions, there will be added inducements to meet in localities not generally visited by the Association.

Under the heading of field work, two significant reports on methods may be mentioned. Preston E. James presented an extensive series of maps as the result of his work in the Blackstone Valley, "The Blackstone Valley of Massachusetts, a Type Study in Southern New England Landscape." The general map displayed the utilization of the land, and the detailed maps brought out more clearly contrasted urban and rural areas. A ready following of such a paper is difficult, however, since no uniformity prevails in the symbols used in mapping such information.

The report of a fortnight in the field as an introduction to the year's work at the School of Geography, Clark University, Worcester, Massachusetts, was given under the general title of "A Geographical Survey of the Greenfield, Massachusetts, Area." The work on the physiography and the physiographic evolution was described by W. W. Atwood; that on the land utilization by W. Elmer Ekblaw; and the climatology by Charles F. Brooks. A fourth paper in the series on the industrial studies in Greenfield and Turners Falls, accredited to Clarence Jones, was briefly covered by W. W. Atwood. As in the previous paper, the maps were difficult to follow because of "homemade" symbols. The work was carried on in the Connecticut Valley in Massachusetts about eighty miles from Worcester, and for the period the students were encamped on an abandoned farm. The field work was directed definitely towards such a study of the area as would yield to the people there living some additional knowledge of their surroundings that could be capitalized.

Papers at Other Sessions

Since the geographer today believes that the true field of his endeavors lies in the realm of regional geography, it is not surprising that the bulk of the papers of the meeting were of this nature. S. van Valkenburg (introduced), from a long experience on the island of Java, gave a careful analysis of the conditions obtaining there in a paper on "Java and Overpopulation" and emphasized particularly the outlook for the future in the face of a rapidly increasing population. The standard of living in Java is upward in spite of the increase, and this indicates that the overpopulation threat is really not yet overshadowing. Measures are being instituted to postpone overpopulation by increasing the productive areas and by more intensive cultivation. Neither manufacturing nor emigration can be looked upon as a possible solution. The papers of Robert S. Platt, "Field Study of an Iron Range Community: Republic, Michigan"; of Glenn T. Trewartha, "A Regional Geographic Study in Eastern Shizuoka Prefecture, Japan"; of W. Elmer Ekblaw, "Resources and Industries of Danish Greenland"; and of Roland M. Harper, "Some Regional Statistics of Ages and Families in Alabama" illustrate the breadth and scope of the offerings.

Apart from the papers in the symposium, two meteorological papers were presented, both by Oliver L. Fassig: "Rainfall in the West Indies and Adjacent Areas of Central and South America" and "Some Characteristics of Tropical Climates." Papers on the content of geography and allied topics have been remarkably absent from the program of the Association during recent years, possibly because such papers have a more ready response in the meetings of the National Council of Geography Teachers. The retiring president frequently draws from this field, as

was the case this year. Another paper in this category was presented by C. C. Huntington (introduced) on "Geography as a Social Science." In the same way the purely physiographic paper is becoming a rarity, "Glacial Land Forms in the Sierra Nevada, Near the Southern End of Lake Tahoe" by Wellington D. Jones representing alone this branch of geography. Mr. Jones described an almost unreported region of peculiar interest.

A very interesting and suggestive paper was offered by Mark Jefferson, "The Geography of Railway Transportation in 1920–27" in which maps of the railroads of the continents were shown as bands twenty miles wide. The map of Europe thus constructed located all places in Central Europe within ten miles of a railroad. This area, the "map web," stopped abruptly at the Pyrenees and the former Russian boundary. A similar condition appeared for the eastern United States with the exception that the transition from the densely railed sections to the less dense was gradual.

Altogether forty-six titles, not counting the presidential address, appeared upon the program. Three papers were read by title, four were not given because of absences, and thirty-nine were presented. The annual dinner on Wednesday evening was a joint session with Section E of the American Association for the Advancement of Science and was held in Scarrett College. At this time two addresses were given: that of G. H. Ashley, retiring Vice-President of Section E, on "Geology and the World at Large," and of M. R. Campbell, retiring President of the Association, on "Geographic Terminology."

Two members of the Association died during the year. The memorial to Charles Redaway Dryer was read by C. C. Colby and that to Ruliff Stephen Holway by V. C. Finch.

National Council of Geography Teachers

The thirteenth annual meeting of the National Council of Geography Teachers was held on December 27 and 28 at George Peabody College for Teachers. At the annual dinner on Tuesday evening, Robert G. Buzzard, the retiring President, gave his address on "A Type of Field Work for the Training of Teachers." Following this address, D. C. Ridgley gave the story of the first college cruise around the world, "Around the World on the S. S. Ryndam," and W. W. Atwood explained from the teacher standpoint the experiment with field work undertaken at Clark University.

The Tuesday morning session had for a general topic courses of study and methods in Teacher Training institutions, and the Wednesday morning session was devoted to types of presentation. At the Tuesday afternoon session E. E. Lackey spoke on "Imparting the Philosophy of Geography to Teachers"; R. H. Whitbeck on "The Making of a Geography Teacher"; and Mark Jefferson on "A Systematized Pronunciation of Place Names." This organization has become within its brief existence a very thriving group, and the discussions and papers cater to many who have no connections with other organizations.

R. M. Brown

AMERICAN GEOGRAPHICAL SOCIETY

Meetings of December and January. The regular monthly meeting of the American Geographical Society was held on December 20, 1927, at the Engineering Societies Building, 29 West 39th Street, President Finley in the chair. Mr. James L. Clark of the American Museum of Natural History gave an account of the journey of the Morden-Clark expedition from Bombay to Peking in 1926, "Across the Snows and Deserts of Asia." In search of natural history collections the expedition penetrated the Russian Pamirs and Chinese Turkestan, eventually crossing Mongolia, where the members were held captive for a time, to the Trans-Siberian railway. The lecture was illustrated by motion pictures of unusual interest.

The Annual Meeting of the Society was held on January 24, 1928, at the Engineering Societies Building, 29 West 39th Street, President Finley presiding. After the reading of the annual report of the Council (printed below) an address was given by Dr. Matthew Stirling on "An Airplane Expedition to the Pygmies of New Guinea," an expedition made under the auspices of the Smithsonian Institution and the Dutch Government. The Stirling New Guinea Expedition spent eleven months in the jungle, part of the time living with the pygmies and taking motion pictures of the details of their daily life. To reach their country an airplane was employed, and thus the expedition avoided the hazards of river navigation and the dangers of travel among hostile savages that had halted earlier expeditions.

February Meeting and Presentation of the Charles P. Daly Medal to Professor Alois Musil. At the meeting of the Society held February 21 the Charles P. Daly Medal of the American Geographical Society was presented to Professor Alois Musil of Prague, in recognition of his contributions to Arabian geography and history through 30 years study, during which many seasons were spent in the field. The results of Professor Musil's intensive labors are being made known through the interest of Charles R. Crane, Esq., who has enabled the Society to undertake their publication. In presenting the medal President Finley spoke as follows:

"When Doughty, the traveler (who fifty years ago was out in the region of which we are to hear tonight), returned to Damascus, pacing the long street called Straight, he met an old friend who said: 'Tell me, since thou art here again in the peace and assurance of Allah and whilst we walk, as in the former years, toward the new-blossoming orchards full of the sweet spring as the garden of God, what moved thee, or how couldst thou take such journeys into the fanatic Arabia?'

"We put a like question tonight to our distinguished guest who has wandered in the same desert places and still others, but we think of it rather as 'Araby the Blest' whose winds 'blow Sabean odors.'

"From my own slight experience in camel riding I think that our guest's journeying of 13,000 miles on camelback is an achievement of the first order. These ships of the desert are never in a calm except when they are at anchor. There is the incessant rocking as of a ship in a high sea. I suppose that after a time one does become accustomed to the motion and overcome the *mal de chameau*, but I have great initial respect for a man who has sailed halfway round the world (in distance) in such a craft and most all the way over desert sands. So I put Dr. Musil in a class with the world's great aviators and navigators.

"But his title to fame is not the distance he has traveled or the manner of his travel, but the wisdom with which he has observed what he has seen in his travels and the linguistic ability and the intellectual zest which enabled him to interpret

what was written in many languages, from the cuneiform inscriptions to modern Arabic, including on the way Greek, Latin, and Syriac. As one of whom Ovid spoke: 'He delighted to wander in unknown places, the labor being lessened by his zeal for information.' To describe in American geographical terms the area which he covered: it would extend if superimposed on the United States from New York City to the eastern boundary of Indiana and from the northern boundary of North Carolina into the forests north of Montreal.

"This region is of universal interest because it includes what he believes to have been the Garden of Eden and Mt. Sinai, the wilderness route of the exodus of the Children of Israel and the Land of Midian whither Moses fled from the face of Pharaoh, kept the flocks of his father-in-law Jethro, and saw behind the mountain the burning bush that was not consumed. It also includes the home of Bedouin tribes, to the mightiest of which he was admitted and made a sheik—a real sheik.

"Charles M. Doughty, the author of that monumental work, 'Arabia Deserta,' said that the books of the Turks and the Arabs 'were men's faces and their living experiences of mankind.' It is such books that Dr. Musil has read afresh and translated into the six volumes which, by a generous subvention from the Hon. Charles R. Crane (whose son is here tonight), the Society has been enabled to publish. In their content they will deserve lasting companionship with Doughty's two volumes telling of the Bedouin's life, of which Colonel Lawrence says: 'It has air and winds, sun and light, open spaces and great emptiness'—yet an emptiness in which every individual has an opportunity to assert himself.

"At the abrupt end of Doughty's 'Arabia Deserta' he tells of the injunction which the Sherif of the Hejaz sent to all the tribes and villages of his dominion:

'That in future, if there should arrive any stranger among them, they are to send him safely to the Sherif'; 'for who knows,' Doughty adds, 'if some European may not be found another time passing that way.'

"Many others have since passed that way, notably that wandering scholar, D. G. Hogarth, whom I had the great privilege to meet out on the edge of that land and who, to the world's infinite loss, has recently died; and his pupil, the enigmatical Colonel Lawrence, whom I also encountered during the war in the city from which Doughty set out; and then this great traveler and scholar, Dr. Musil, upon whom I now have the honor to confer the Charles P. Daly Medal in recognition of his contribution through travel and research to the body of geographical knowledge."

In accepting the medal Professor Musil said:

"A sailboat on a stormy sea; a helmsman using all his mental and bodily strength to bring his boat with its load to a sure harbor. How it reminds me of the sand storms in the desert and of my own strain and struggle to save my life and the results of my investigations; investigations that should be made accessible to any who are interested in the growth of our civilization.

"How grateful am I to Allah who brought me to the American Geographical Society and moved its Council to publish my works. Nobody in the world would have taken better care of these my children than the editor, Dr. Wright.

"Dr. Finley, I thank you for the Daly Medal and congratulate you upon being the President of the American Geographical Society."

Professor Musil then delivered an illustrated address on "Desert Life in Northern Arabia," in which, besides describing something of the daily life of the Bedouins, and picturing their geographic environment, he interpreted the spiritual reaction of the nomad to the desert scene.

Elections to Fellowship. At the December, January, and February meetings of the Society, President Finley presiding, there were presented with the approval of the Council the names of 146 candidates, who were duly elected as Fellows of the Society.

Annual Report of the Council

New York, January 24, 1928

To the Fellows of the Society:

To contribute to the advancement of geographical knowledge in all of its far-reaching relations is the Society's aim in its periodical publication, the *Geographical Review*. A reference to some of the more important material published therein during 1927 will indicate how this policy has been maintained.

The North American field is well represented in a variety of topics, ranging from problems of today, exemplified by the paper of Mr. Philip W. Henry, on "The Great Lakes-St. Lawrence Waterway," and of Dr. R. M. Brown, on "The Utilization of the Colorado River," to problems of historical geography such as Dr. Halldór Hermannsson's investigation into the question of the Wineland Voyages; while the two meet in Sir Patrick McGrath's account of "The Labrador Boundary Decision."

Two outstanding illustrated papers in the South American field are by Mr. Holstein on "Chan-Chan: Capital of the Great Chimu," one of the great cities of the western hemisphere of pre-Columbian times, and by Mr. Rudolph on the "Rio Loa of Northern Chile," a comprehensive survey of the chief river basin of the Atacama Desert. Also notable for its well-selected illustrations and for unusual picturesqueness of theme and treatment is Miss Semple's study of "The Templed Promontories of the Ancient Mediterranean." An intimate account of anciently preserved folk customs and characteristics in Hungary by the Rev. E. D. Beynon makes contrast with the theme of "Southern Rhodesia: A White Man's Country," by Mrs. Tawse-Jollie, member of the legislature of that newly constituted self-governing colony, or of Dr. Dixey's "Mlanje Mountains of Nyasaland," a description of physical aspects and economic prospects, by the government geologist of that protectorate.

In "Northern Arabia: The Explorations of Alois Musil" Dr. J. K. Wright, librarian of the Society and editor of its series *Oriental Explorations and Studies* summarizes and illustrates the great geographical contributions made by Professor Musil in thirty years of research.

The first year's field work of the Greenland Expedition of the University of Michigan described by Professor Hobbs makes an important contribution to our knowledge of the physiography and climatology of western Greenland. The opposite shore of the great island is the subject of a narrative, "The Colonization of Eastern Greenland: Eskimo Settlements on Scoresby Sound" by the Danish explorer, Ejnar Mikkelsen, a moving spirit in the enterprise. In "Interior Basin Drainage" Professor De Martonne gives the results of many years' work on a problem of fundamental importance in physical geography. Under the epigrammatic title of "World Unity" Professor Chisholm expounds his geographical philosophy.

Altogether the *Geographical Review* in 1927 included 39 leading articles, 73 items of geographical record, and 75 reviews. In addition to the many text maps and diagrams there were two insert maps in color and one in black and white.

Among the books and maps in course of publication by the Society during 1927 may be mentioned the following:

1. Problems of Polar Research, by thirty-one authors.

This book is a coöperative undertaking written by thirty-one of the leading authorities on polar problems. It is helpful to the layman and the scientist alike in that it informs the layman of the underlying purpose of polar exploration and assists the scientist by making available to him the plans and ideas of experts for the benefit of future exploration.

2. The Geography of the Polar Regions, by Otto Nordenskjöld and Ludwig Mecking.

This is a companion book to Problems of Polar Research. It constitutes the most complete regional reference book in English in polar geography.

These two books on polar research were produced in an effort to center attention upon the major problems remaining to be solved by further field study, to discover where and by what means it may best be attacked, and to suggest the form of coöperation between the sciences most concerned that would yield the largest harvest of results. The Society is deeply indebted to the thirty-three authors concerned for their willingness to join in making a fresh examination of the unsolved problems that inspire modern polar exploration. It is hoped that increasing support for well qualified expeditions may be one result of the publication of this comprehensive group of distinguished papers.

3. THE CORAL REEF PROBLEM, by William Morris Davis.

This volume contains the results of the author's original field studies extending over a period of ten years together with a review of the work of scientists who have interested themselves in the problem for nearly a century. It is a worthy successor to Darwin's classic study of coral reefs and demonstrates the essential soundness of Darwin's conclusions.

4. THE LAST GLACIATION, WITH SPECIAL REFERENCE TO THE ICE RETREAT IN NORTHEASTERN NORTH AMERICA, by Ernst Antevs.

A world survey of Pleistocene glaciation with a detailed study of the clay layers in the Hudson and Connecticut Valleys and Canada in continuation of THE RECESSION OF THE LAST ICE SHEET IN NEW ENGLAND, by the same author, published by the Society in 1922.

5. PRACTICAL HINTS TO SCIENTIFIC TRAVELLERS, Vol. 5.

This volume, the fifth in the series which is being published at The Hague by Professor H. A. Brouwer, contains articles by authorities on Ecuador, Eastern Congo, North Manchuria and the Russian Far East, and the Malay Peninsula.

6. ARABIA DESERTA, by Alois Musil.

In the report for 1926 attention was called to the publication of the first of a series of six volumes on Arabian geography and history prepared by Professor Alois Musil. During 1927 the second volume, entitled ARABIA DESERTA, was published. At the close of the year the third volume was in the hands of the binder. Publication of the entire series will be completed by the end of 1928.

7. THE LEARDO MAP OF THE WORLD, 1452.

The Society is publishing a full-size colored reproduction of the world map of Giovanni Leardo (1452 or 1453), the original of which was acquired in 1906. The reproduction is accompanied by an illustrated descriptive book of 89 pages.

8. BIBLIOGRAPHIE GÉOGRAPHIQUE.

The Society has continued its coöperation with the Association de Géographes Français in the publication of the BIBLIOGRAPHIE GÉOGRAPHIQUE, a fundamental international geographical bibliography. To the number for 1925 the Society's staff contributed about 350 bibliographical references and 125 brief reviews.

9. A map of NORTHERN ARABIA on a scale of 1:1,000,000, based on Professor Musil's original surveys, was published during the year. This map, which illustrates the second, third, fourth, and fifth volumes of Professor Musil's work, is printed in black and brown in four sheets.

10. In the *Geographical Review* the following insert maps have been published: a map of Interior Basin Drainage, by E. de Martonne and L. Aufrère, to accompany Professor de Martonne's article on the subject; a map of Scranton, Pa., showing land utilization, to accompany an article by Clifford M. Zierer on Scranton as an urban community; map of Lyme, N. H., in 1830, 1860, 1892, 1925, to accompany the article by J. Walter Goldthwait entitled "A Town That Has Gone Downhill."

11. Millionth Map of Hispanic America.

The final printing of several of the twenty sheets of this map which were announced in the last annual report has been greatly delayed by a strike at the firm which is lithographing and printing the map. The last of the sheets are now being printed, however, and will be ready for distribution by the end of January.

Good progress has been made during the year in the assembling of source material and the compilation and fairdrawing of additional sheets. Fairdrawing has been completed on ten sheets, and the fairdrawing of four others is in progress. Compilation has been completed on six others, and eight more are in process of compilation. The coöperation of the many institutions and companies who have contributed to the Society's collection of source material for the map has continued, and a large number of important surveys has been added to the collection. Several of the Hispanic American governments have shown their interest in the map by contributions of important surveys, the greater part of which are unpublished. This has been particularly notable in the case of the government of Ecuador, which has sent to the Society the entire collection of original surveys from the archives of the Department of Public Works. The collection was sent in charge of Colonel Luis T. Paz y Miño, Sub-Secretary of War and noted Ecuadorean explorer and cartographer, who has been commissioned by his government to assist in the compilation of the Ecuadorean sheets of the map.

Field Expeditions

The Society is able occasionally to lend instruments to well-qualified expeditions and to provide specially prepared maps and tables for the use of field parties. More direct encouragement has been given during the year under review to four expeditions engaging in exploration of high geographical promise. The Putnam Baffin Island Expedition, whose geographical work was done under the auspices of the Society, left New York in June and returned in October. In the short open season of the Foxe Basin several lines of sounding were made as far north as the entrance to Fury and Hecla Strait, the basin being navigated for the first time in a hundred years; and the coast line of northern Foxe Land was charted for the first time, giving a part of the western coast of Baffin Island an entirely new position. Mr. George Palmer Putnam, director of the expedition, deserves high praise for his businesslike organization and conduct of the whole expedition. A report on the results of the expedition was published in the *Geographical Review* for January, 1928.

In continuation of his program for several years' exploration in the Arctic basin, Captain George H. Wilkins secured additional equipment early in the year and in March made a flight of 550 miles due northwest of Point Barrow, alighting on the ice safely. His position was longitude 175° W., latitude 77°45′ N., or almost midway between the tracks of the *Jeannette* and the *Norge*. With an echo depth finder provided by the Society he was able to make a sounding, obtaining as a result 5440 meters, the greatest depth so far discovered in the Arctic basin. On the return a second and eventually a third landing was made on the ice, Captain Wilkins and his pilot, Ben Eilson, returning on foot to Point Barrow after the exhaustion of the fuel supply. In 1928 Captain Wilkins proposes to fly northeast of Point Barrow, if possible to the site of "Crocker Land."

In pursuance of the policy of the Society to add to its collection of original surveys for compilation in the Millionth Map of Hispanic America by conducting surveys of its own in critical areas, a party was sent to Peru in June under the leadership of Mr. O. M. Miller, of the Society's School of Surveying, to make a topographic survey of the headwaters of the Marañon River and to carry out a number of traverses in the montaña between the Marañon and Huallaga Rivers in order to tie together a number of earlier surveys by various explorers. Mr. Miller's last report stated that the surveys at the headwaters of the Marañon had been completed and that the work in the

montaña was under way. The government of Peru has shown great interest in the plans of the expedition and has supplied a military escort and otherwise greatly facilitated the work.

In September Mr. and Mrs. Joseph H. Sinclair left for Ecuador to carry out a program of surveys and geographical and geological studies in the Oriente region of Ecuador under the auspices of the Society. They will continue the survey work begun by Mr. Sinclair and Mr. Theron Wasson in 1921. The special objective of the expedition is Mt. Sumaco, a volcano which was located by the expedition of 1921 and which the present expedition proposes to study and map. The surveys made by this expedition will be a very important contribution to the source material for the Map of Hispanic America since they will cover one of the least-known regions in South America.

The School of Surveying

During the year many people have consulted the School for technical information on surveying and astronomical subjects, especially in the field of aerial survey. Six field expeditions were lent instruments and provided with various charts and accessories. The School library has been organized and indexed, and an international survey periodical service has been established.

New instruments added to the School's equipment during the past year include three wireless sets, a barograph, and two plane tables of aluminum designed for portability. The Radio Broadcast Laboratory of Garden City has coöperated with the School in the design and production of field wireless time-signal reception apparatus with the result that there have been in use during the year two sets weighing only twenty-three pounds, including batteries, and yet capable of receiving anywhere in the world one or more time signals of the order of excellence of Arlington, Rugby, Eiffel Tower, Nauen, Honolulu, or Saigon. If the governments of the world could agree to send scientifically accurate time signals on wave lengths of the order of thirty to forty meters an exploration time-signal set could be made to weigh less than six pounds with corresponding simplification of design.

The computation of star time-tables in connection with the equal altitude method has progressed rapidly. The object of these lists is to obviate the necessity of computing a star program in the field.

In April, Mr. Weld Arnold went to Guatemala in connection with the boundary work of that country, but the beginning of the rainy season and a change in the personnel of the government brought about his return in July. Mr. Miller's work in Peru is described in an earlier paragraph.

Population Studies in the United States

The Society is now enabled to begin a series of specialized studies upon the population of the United States. These will be made region by region, New England being the first field of investigation in view of the highly critical state of its agricultural and part of its industrial population. From the related subjects of economics and sociology contributions will be sought to make a well-rounded study of the history of settlement with a view to furnishing an essential background for the conditions of today. It will be understood that population studies in the United States are necessarily coöperative, for many types of investigation are needed to reflect the nature of our diversified country.

The Scientific Study of Settlement

Excellent progress has been made in the study of pioneer belts during the past year. This project, originally presented to the National Research Council in 1925, was endorsed by that organization and recommended to the Social Science Research Council. A committee of each council gave the subject a thorough examination, and

eventually support was obtained to provide for a study of wide scope. As a beginning a book by twenty-five or thirty authors will be prepared, similar to the volumes on polar research in wideness of scope, with emphasis on problems of immediate concern in the settlement of undeveloped lands.

The Canadian government and a committee of Canadian scientists have cordially joined with a committee of the Social Science Research Council in outlining (and eventually in administering) a program of study adapted to Canadian conditions. A part of the intensive study now in process of organization will relate to marginal lands in the United States. At a later time the coöperation of governments and institutions most concerned will be sought to advance similar studies in the remaining pioneer lands of first importance. Two papers outlining the problem are: "The Scientific Study of Settlement" (*Geogr. Rev.*, Oct., 1926) and "The Pioneer Fringe" (*Foreign Affairs*, Oct., 1927), the latter illustrated with a first tentative world map of pioneer regions.

Distribution of Publications to Graduate Students

To encourage graduate students in geography in the various universities of the United States the Society distributed during 1927 sixty sets of books and periodicals published by the Society in recent years. The students selected were those recommended by the geographical departments of the leading universities and colleges, and for the most part included men and women who are entering geography as a profession. The responses have been most encouraging.

Library Organization

Additions to the library during the year comprise 966 books, 415 pamphlets, 9706 new issues of periodicals, 1893 maps, and 62 atlases.

The library has continued its activity in accordance with the principles explained in the report for 1926. Cards representing over 2000 books, pamphlets, periodical articles, and maps were entered in the special research catalogue. A survey of missing volumes in the files of publications of geographical societies has been made, and the library is endeavoring to fill the gaps.

During the year the library coöperated with the New York Public Library in compiling a list of maps of New York. It also coöperated in the publication of the Union List of Periodicals and the Bibliographie Géographique. An author index to the research catalogue was completed, and a list of geographers in the United States compiled.

The Lecture Program

The speakers and titles upon the Society's lecture program during the past year are as follows:

H.R.H. Prince William of Sweden, "Exploration in the Land of the Pygmies"; Dr. John C. Merriam, "Cave Exploration and the Antiquity of Man"; Professor William H. Hobbs, "The First Greenland Expedition of the University of Michigan"; Sir Curtis Lampson, "Across the French Sudan to Timbuctu"; Dr. Samuel K. Lothrop, "Aboriginal American Culture and the Geographical Environment"; George Palmer Putnam, "Exploration in Baffin Island"; James L. Clark, "Across the Snows and Deserts of Asia."

Medal Award

The Charles P. Daly Gold Medal of the Society was awarded to Professor Alois Musil of the Charles University, Prague, in recognition of his distinguished explorations in and scholarly books on Arabia. Presentation of the medal will be made at the February meeting of the Society.

The number of Fellows at the close of the year was 5195, of whom 398 are Life Fellows. In addition there are 5 Honorary Members and 35 Corresponding Members.

The report of the Treasurer submitted herewith gives a condensed balance sheet and a summary of the income and expenses of the Society.

PHILIP W. HENRY
Chairman

REPORT OF THE TREASURER FOR 1927

RECEIPTS AND EXPENSES

During the year there have been received from annual dues, interest on investments, and sales of publications	$77,312.28
There have been expended for salaries, house expenses, library, meetings, publications, postage, insurance, etc.	94,451.83
Balance charged against Special Deposit Fund	$17,139.55

CONDENSED BALANCE SHEET, DECEMBER 31, 1927

Cash	$13,554.51
Sundry balances and investments	87,152.49
Inventory of publications	8,607.14
	$109,314.14
Capital Account, Balance uninvested	4,322.20
Annual dues paid in advance	5,058.56
Special Fund for general purposes	33,150.94
Sundry deposits and reserves	35,801.08
Millionth Map Publication Fund, Balance	30,981.36
	$109,314.14

REPORT OF THE SPECIAL COMMITTEE

New York, January 19, 1928

The Committee appointed at the meeting of the Council held on December 15, 1927, to nominate officers for the vacancies to occur in the Council in January, 1928, beg to nominate the following named gentlemen for the offices designated and move that the same be approved and presented to the Society for election at its meeting to be held on January 24, 1928:

		Term to expire in
President	John H. Finley	January, 1929
Vice-President	James B. Ford	January, 1931
Recording Secretary	Hamilton Fish Kean	January, 1931
Foreign Cor. Secretary	Frederic C. Walcott	January, 1930
Treasurer	Henry Parish	January, 1929
Councilors	Philip A. Carroll Archer M. Huntington	January, 1931

John Greenough
W. Redmond Cross
Paul Tuckerman
Committee

GEOGRAPHICAL RECORD

NORTH AMERICA

The Winter Maintenance of Highway Transportation. The last two decades have seen a great revival of highway transportation so largely superseded by canals and railroads in the last century. The passenger automobile and the motor truck are revolutionizing living conditions in both town and country. The rapidity of the movement is graphically shown in the road surveys recently issued by various states. Take for instance the "Report of a Survey of Transportation on the State Highway System of Ohio" by the Bureau of Public Roads, U. S. Department of Agriculture, and the Ohio Department of Highways and Public Works (1927). From it we learn that the State Highway Department spent $460 on roads in 1905 and $17,000,000 in 1926 and a total of over $95,000,000 in the 22-year period. During this time almost as much was expended by the counties, and a substantial sum was received from Federal aid. In 1925 Ohio had approximately 85,000 miles of rural highway, of which 13 per cent constituted the state highway system. The motor vehicle movement was estimated at three and three-quarter billion vehicle miles, of which more than half was carried by the state highways. In 1913 Ohio had 59 persons to a car; in 1925 less than 5. Among the several maps accompanying the report one on a scale of 12 miles to the inch, showing the volume of traffic along the highways and the distribution of population, affords a striking illustration of the close relation between urban development and highway traffic.

The vast outlay upon highways and the dependence placed upon them—by mail, school, and medical services, for instance, as well as the ordinary goods and passenger traffic—demand continuation in use. The greater part of the United States, however, is faced with the problem of suspension of road circulation for a longer or shorter time during the winter months. How the problem is being met is told in the Snow Removal Reports of the Bureau of Public Roads, digests of data furnished by state officials for the "thirty-six snowfall states." The report for the winter of 1925–1926 is an interesting document which, in addition to statements on progress of the work, gives some discussion of the general problem. A map of the United States on a scale of 100 miles to the inch shows the roads kept open for winter traffic in the regions of heavy snowfall and also the depth of snowfall by contours from the Atlas of American Agriculture; a separate map shows the average annual number of days with snow cover from the same source. In general the snowfall states have over 10 inches of snowfall and over 10 days duration of snow cover. Apart from the mountainous West the areas of heaviest snowfall are the Michigan peninsulas and the northern parts of New York and the New England states, with over 60 inches. Likewise these areas, with a westward extension through North Dakota, have a snow cover of over 90 days' duration. The chief difficulty in snow removal is caused by drifting, for snow rarely falls to a depth exceeding 9 inches in individual storms in the non-mountainous areas. The problem is worse in the colder regions, where the snow is dry and drifts more readily. Much can be done in the way of prevention; for instance, by the removal of hedges or tight fences so disposed along the roads as to cause drifts. Artificial protection is afforded by the construction of snow fences placed suitably in relation to the wind. The state of Michigan is acquiring rights of way 400 feet wide through wooded land, trees and brush being left to act as drift preventives.

The rapid progress in snow removal on state roads may be seen from the tables accompanying the report for 1926–1927. In the winter of 1922–1923 the mileage

of roads from which snow was removed was 27,000; in 1926–1927 it had increased fourfold: the equipment of truck plows and tractor plows, 405 in 1922–1923, was increased to 3896 in the same time.

Mt. Multnomah, a Cone-Filled Caldera of the Cascade Range. Crater Lake, occupying a great caldera formed by the engulfment of the hypothetical cone of Mt. Mazama on the dissected highlands of the Cascade range in southern Oregon, is already famous. A still greater, yet less known caldera, once occupied by a larger lake but now in part filled by cones of later eruption, represents another hypothetical cone, presumably 15,000 feet high in its prime and measuring over 50 miles along the radius of its lava flows, for which the name of Mt. Multnomah has been proposed and of which an admirable description has been prepared by E. T. Hodge, professor of economic geology in the University of Oregon (Mount Multnomah: Ancient Ancestor of the Three Sisters, University of Oregon, Eugene, Ore., 1925). Its remains crown the highlands of the Cascade Mountains at an altitude of 5000 feet, about midway between the northern and southern borders of Oregon. The highlands, which have a breadth of 75 miles, descend to the east with a gradual and moderately dissected slope; but to the west, where the rainfall is greater, their more rapid descent is diversified by deep-cut valleys. The crest line between the two descents is known as the "break" of the range and is followed by the Skyline trail southward from Multnomah for 250 miles past many other superposed and more or less dissected volcanic cones.

The great Multnomah caldera, admirably shown in a generalized diagram, now rises in a number of crests with in-looking cliffs, of which North Sister, Little Brother, Husband, Wife, and several other members of the gigantic family are the chief summits. The other two of the Three Sisters are later-formed, caldera cones, from which lava streams have flowed down through erosional gaps in the caldera rim. The higher mountains have been rather strongly glaciated, as shown in Figure 24; some of them bear diminished glaciers today. Recent lava flows, some of them cascading down cliffs, others collapsing in doubled ridges, are well generalized in Figure 26.

The later pages of this most attractive essay contain sections on springs, lakes, streams, flora, and fauna. The only ground for adverse criticism is found in the statement that the Glacial period here was closed by a sinking of the Oregon fault block: this is questionable, because most regions from which Quaternary glaciers have disappeared give no sufficient evidence of having sunk enough to melt their ice streams. On the other hand, the essay as a whole is exceptionally intelligible, partly because of its well reasoned explanations and its well ordered presentation, partly because of the unusual excellence of its many illustrations. The region described must be of superb scenic attractions.

W. M. Davis

A Soil Map of Florida. The Seventeenth Annual Report of the Florida State Geological Survey (Tallahassee, 1926) contains a generalized soil map of the state by Roland M. Harper. The map is on a scale of 1:1,000,000 and shows 11 soil types, briefly characterized in the legend, described more fully in an accompanying text. The amount of swamp land in the state is not so large as is commonly thought. About two-fifths of Florida is rolling or hilly upland with very little swamp; of the remainder—flatwoods, muck, marl, and other level areas—about one-fifth is perpetually saturated or subject to inundation. About 80 per cent of the soils may be described as sand. The fertility is generally low, the average being probably less than in any other state in the Union. Cultivated or improved land formed only 2 per cent of the total area in 1880, and 6.5 per cent in 1920, and did not increase in the next pentad; although, according to the State Census for 1925, there was a corresponding

increase in population of 30 per cent. However, in Florida soil fertility is not an index to farm value. Through the extensive use of fertilizer, the selection of crops, and general superiority of methods the value of farms in central and southern Florida, with its poorer soils, greatly exceeds that of the more fertile north (see R. M. Harper: Agricultural Conditions in Florida in 1925, *Econ. Geogr.*, Vol. 3, 1927, pp. 340–353). The average for the state is above the average for the country as a whole and so is the value of crops per acre.

SOUTH AMERICA

The Economic Status of British Guiana and Its Improvement. The economic history and present status of British Guiana are succinctly presented in the following table from the Report of the British Guiana Commission, 1927 (Cmd. 2841).

	Population	Exported Sugar Tons	Value of Sugar and By-Products Exported £	Total Value of All Exports £	Percentage of Sugar, Etc., to All Exports
1836	98,000	59,000	1,847,786	2,135,379	84
1925	304,000	97,000	1,551,745	2,967,096	53

The Report goes on to say: "For the appreciation of the full implications of these figures it is necessary to add that the increase in population was entirely due to assisted immigration of labour for the plantations and not to any natural increment; that throughout this period the area under sugar has steadily declined; that the whole rise in sugar exports shown had been achieved over forty years ago since when production has remained stationary with a tendency to diminish; and that the relatively smaller proportion of sugar exports to total trade is almost entirely due to a sudden rise in the output of alluvial diamonds which cannot be regarded as a stable or permanent factor in the economy of the Colony."

While natural obstacles are held responsible in the main for the condition of stagnation, other causes have been contributory, not the least of which is the political constitution, an heritage from Dutch colonial days. Amends in this respect are likely to follow the recently issued report of a local commission as a White Paper.

The recommendations of the Parliamentary Commission include the diversification of agriculture in the alluvial belt, the introduction of the groundnut being specially urged. The remarkably successful cultivation of this crop in Nigeria is instanced. The export of groundnuts from Nigeria is at present exceeded in value only by that of palm oil and kernels, and this though the bulk of the crop comes from the Kano region, 700 miles from the seaboard. At present only 140,000 out of 3,500,000 acres of the coast belt of British Guiana are under cultivation. Drainage and irrigation works, already begun, should be continued under government control. The crying need of population remains. The Commission suggests that the overpopulated islands of the West Indies, notably Barbados (940 per square mile) and Jamaica, should be looked to as a source in preference to India, until 1917 for many years the major source of immigration into British Guiana. The terms recently proposed by the government of India for resumption of the East Indian immigration would involve heavy expenditure on the part of the colony.

The alluvial belt occupies six per cent of the total area of the colony; a somewhat larger area of the interior is open country; the rest, 87 per cent, is forest-covered. A few years ago a Forest Department was created, and systematic investigation of the colony's great timber resources began. In 1926 the Department explored,

mapped, and evaluated an area of some 650 square miles between the Essequibo and Mazaruni Rivers. The outstanding feature of the area is "the greenheart forests which were found over the best compact self-contained area of 70 square miles to compose 31 per cent of the total crop, a most unusual density in a virgin tropical forest."

The Department is now turning its attention to the North-West District, "nearly 10,000 square miles of undeveloped country, mostly under primary forest and occupied by a population of 11,000 persons, half of whom are aborigines." In this connection it is noted that the aborigines have been of much service to the investigators and that they make excellent woodsmen. For mutual benefit it is suggested that care of the natives be transferred to the Conservator of Forests.

Today the only large contribution to the export trade from the interior is made by diamonds (28 per cent), although good progress has been made in the production of bauxite (6 per cent) since the industry was started in 1916. The proved diamond field of some 1200 square miles in the middle portion of the Mazaruni basin has been the subject of a recent government survey, whose prime object was determination as to whether the diamond and other mineral resources of the alluvial deposits would justify construction of a railroad to the fields (H. J. C. Conolly: Report of the Preliminary Survey of the Mazaruni and Puruni Diamond Fields, British Guiana, March–December, 1925, Part I). The conclusions are not favorable to a project based on mineral prospects alone. There are many advocates of railway building as a means of opening up the interior. A proposed route, now under investigation, would run from Bartica or some point on the Essequibo in reach of ocean-going steamers to the Tiboku Fall whence safe navigation on the Upper Mazaruni begins. But, as the Commission points out, a railroad will not of itself bring about the development of the colony; and the failure of the interior railroad of Surinam, 150 miles long, is cited.

Snowstorms in the Central Valley of Chile. In a region where snow seldom occurs more than once in a lifetime its almost annual recurrence in the last few years challenges explanation. History records but eight snowstorms in the Central Valley of Chile between the founding of the colony and 1920, occurring in 1536, 1647, 1832, 1848, 1853, 1891, 1898, and 1912. From 1920 to 1924 it snowed each year; and on September 7, 1927, a sixth snowfall occurred, lasting five hours. The phenomenon is discussed by Julio Bustus Navarrete in the September, 1927, issue of the *Boletin del Observatorio del Salto* (Santiago).

Navarrete locates the snowstorms in the latter half of a period of low pressure and immediately following the line along which the wind shifts from north to south or south-east. A further wind shift back to a northerly direction dispels the cold wave and wipes out all traces of snow. Beyond this point Navarrete accepts and utilizes the theory, and occasionally the exact words, of his predecessor, Benjamín Vicuña Mackenna in "Ensayo historico sobre el clima de Chile," published in 1877. Both authors correlate years of drought with years in which snowfalls occur. Records indicate such correlation in 1647, 1832, 1847, and 1853. Such definitely was the case in 1924. The exaggerated accounts of the length of the snowstorms lasting "ninety-nine hours," "one hundred and eleven hours," and "three days continuously" indicate the traditional quality of the early reports. No snowstorm of the last decade has lasted more than nine hours. No reliable meteorological information exists before about 1860. Records since then in no way substantiate the theory relating snowstorms to periods of drought. Were this theory correct we might have expected snowstorms to follow the unusually dry years of 1869, 1886, and 1892. Conversely, we should have expected none in 1920 since the precipitation in 1919 was nearly double the normal. The concurrence of snow and drought in 1924 seems to have been the exception rather than the rule.

EUROPE

The Present Situation and Trends of the Mineral Industry in Upper Silesia. Before the war the Upper Silesian industrial area was one of the most important in Germany. With regard to coal and iron Bohemia and Poland in 1913 were competitors rather than customers, hence Upper Silesia sought and found her markets in the Fatherland. Raw materials came from the north and west, and the markets were located in those directions. The network of local railways and canals uniting the area and the direction of the natural routes helped Upper Silesia to turn its back on its neighbors to the south and east.

Before the war it was in the Industrial Triangle, less than 20 miles in length and about 15 miles in width, that nearly half the population of Upper Silesia was found. Four-fifths of the coal, all of the zinc produced, and nearly all of the metallurgical plants were located in this small area. The new boundary cut the Triangle in two, the larger part being assigned to Poland. The change was obviously a great blow to industry here, in spite of the fact that the League of Nations prescribed certain temporary measures to lessen the shock. Looking back after six years the economic changes can be seen in better perspective, and the results can be more clearly understood than immediately after the partition.

TABLE I—BITUMINOUS COAL OF GERMAN UPPER SILESIA AND PERCENTAGE OF TOTAL GERMAN PRODUCTION

YEAR	PRODUCTION	PERCENTAGE
*1913	11,090,908 metric tons	8
1923	8,744,679 " "	13
1924	10,900,259 " "	9
1925	14,272,687 " "	10
†1926	17,461,659 " "	

* Total German production was 43,170,000 tons of which Upper Silesia produced 23 per cent.
† This figure from *Vierteljahrshefte zur Statistik des Deutschen Reichs*, Vol. 36, No. 3, 1927.

The coal production of German Upper Silesia in recent years is shown in Table I (*Mineral Industry*, Vol. 34, 1925, p. 167, and Vol. 35, 1926, p. 140), the figures referring only to the territory on the German side of the frontier. Two factors have contributed to the increased output: the respite from the duty-free importation of Polish coal, which ended in June, 1925, and the introduction of mechanical improvements in the mining equipment. This latter is well illustrated by the fact that in 1913 there were 420 horses in use, while in 1925 there were only 127. In 1925 there were over seven times as many electric hand drills in use as there were in 1913. These are only two instances of the many, cited in the League of Nations Memorandum on Coal (Vol. 2, May, 1927), which show the transition from manual to machine labor in German Upper Silesia.

The largest reserves of coking coal, of which the supplies are meager, are in the county of Zabrze, and most of the mines here have remained with Germany. On the other hand, much of the coal now being mined at Rybnik is capable of producing coke superior in quality to that of Zabrze, and these Rybnik mines have all been allotted to Poland (for a map see Bruno Dietrich: Oberschlesien, seine Stellung innerhalb der deutschen Ostmark und seine Grenzen, *Verhandl. Deutschen Geographentage*, Vol. 21, Berlin, 1926, pp. 97–112, reference on p. 115; and see P. Dumas: Le partage de la Haute Silésie, *Ann. de Géogr.*, Vol. 31, 1922, pp. 1–14). Germany's loss in this respect is not serious as there are large supplies of coking coal in the Ruhr district. On the other hand Poland gains an important advantage, since the mines

of former Polish territory produce no coking coal. The total quantity of coke produced in all Upper Silesia before the war amounted to two million tons annually, most of which was used in local industries. The total output of coal in Polish Upper Silesia in 1925 amounted to 23,433,630 tons.

Table II shows the export of coal from German Upper Silesia for three years (1923–1925) succeeding the partition of the coal basin with Poland (*Commerce Repts.*, July 5, 1926, p. 40).

TABLE II—EXPORT OF COAL PRODUCED IN GERMAN UPPER SILESIA

(*In metric tons*)

COUNTRY	1923	1924	1925
Poland	60,326	52,979	66,087
Czechoslovakia	17	129,838	553,564
Austria		57,081	121,104
Hungary		16,396	20,488
Other countries		9,166	18,157
Total	60,343	265,460	779,400

In competition with the other coal fields of Germany, Upper Silesia works at a distinct disadvantage. There is first the competition of the Lower Silesian and Saxony fields; farther afield but most important of all domestic competitors is the Ruhr mining region, whose proximity to the entire region west of the Elbe gives it the advantage over Upper Silesia. From the northwest comes a formidable rival in the shape of British coal, as cheap transportation allows this to compete with Westphalian and Upper Silesian coal in the Berlin markets and the North Sea ports.

With these difficulties to meet in the north, it seems likely that expansion of the Upper Silesian coal trade will tend towards the foreign markets to the south and east rather than to the home markets of the northern plain.

Before the war German control of the international zinc market was strong. The German Zinc Syndicate controlled one-half of the world output of zinc and three-quarters of the European production. Next to Belgium, Germany was the greatest exporter of zinc in 1913. In that year Upper Silesia supplied 60 per cent of the German production. Figure 1 shows the output of the chief zinc-producing countries of Europe: (a) before the boundary changes of 1921, and (b) after the territory containing the greater part of the Upper Silesian zinc and lead deposits had been assigned to Poland.

The zinc industry of Polish Upper Silesia made satisfactory progress until about the middle of 1925. The heavy export assessments after that date practically suppressed the industry, as all metals and ores had been passing through Germany and were reduced by German operators. The mine owners on either side of the boundary line were seeking control of the mineral and metal industries. It was a chaotic condition that American interests faced in the fall of 1925 when an option was taken of all the mines, manufacturing plants, etc., of the Giesche Heirs Incorporated, located on both sides of the boundary line. In the settlement of the controversy, as it emerges in 1927, neither German nor Polish control exists in Poland. All mining interests are now possessed by American, Czechoslovakian, British, Belgian, and French capital.

The Giesche holdings taken over by the Harriman Company of New York and the Anaconda Company of Montana comprise zinc mines, smelters, and coal mines.

FIG. 1

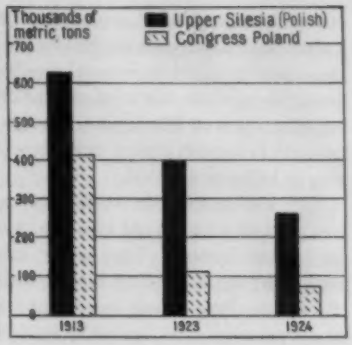


FIG. 2

FIG. 1—Output of the chief zinc-producing countries of Europe. Data from *Mineral Industry*, Vol. 34, 1925, p. 746.

FIG. 2—Pig iron production in Polish Upper Silesia (territory ceded by Germany in 1921) and Congress Poland. Data from *Mineral Industry*, Vol. 34, 1925, p. 419.

The acquisition of these mines, one of the largest bodies of high grade zinc ore in the world, together with the American mines already owned will give Anaconda control of between 16 and 17 per cent of the world's zinc production (*Engineering and Mining Journ.*, Vol. 120, 1925, pp. 781–782). The output of zinc ore in Polish Silesia increased from 268,775 metric tons in 1925 to 337,423 tons in 1926 (*Annuaire Statistique de la République Polonaise*, Vol. 4, 1925–1926 and Vol. 5, Warsaw, 1927), an indication that the American transactions are already having favorable results.

The iron ore deposits of Upper Silesia are less important than those of coal or zinc; but in 1910, 901,366 tons of pig iron (9 per cent of the German output) were produced here. In any attempt to account for the recent changes in the output of iron and steel in German Upper Silesia it must be realized that 97 per cent of the iron ore deposits of this area went to Poland in 1921.

The trend of production of pig iron in recent years in Polish Upper Silesia (which was German territory previous to 1921) and Congress Poland are shown in Figure 2. One reason for the decrease in output is that the ore supplies are giving out. The provisioning of the blast furnaces is largely composed of foreign metal, mostly Swedish. Before the partition of 1921 Upper Silesia produced chiefly heavy forms of steel, such as rails, structural steel, and pipes, which were marketed in southern Germany. With the continued decline in the ore output manufactures of this kind can hardly survive. Those works which specialize in more valuable steel products for the automobile and electrical industries, for German rather than for Polish markets, are the most active; and beyond doubt, if the industry is to continue, it must change to the manufacture of products requiring less raw material but greater skill in the making.

This last year (1926–1927) Poland's iron and steel industry has begun to feel the benefit of the general European revival and is having success in Eastern Europe in competition with Czechoslovakia. Exports have greatly increased as a result of closer relations with Austria, Hungary, Bulgaria, and Jugo-Slavia, while in Rumania, in particular, there has been a conquest over the Czechoslovakian product (*Mineral Industry*, Vol. 35, 1926, pp. 385–386).

E. MURIEL POGGI

Hydro-electric Industry and Labor Problems in the French Alps. In his latest contribution on the hydro-electric development in the French Alps Professor Raoul Blanchard notes some interesting changes in industrial distribution dependent on the problem of labor supply (The Utilization of Water Power in France, *Harvard*

Business Rev., Vol. 6, 1928, pp. 176–187). Silk weaving, at first concentrated in Lyons and after the beginning of the nineteenth century spreading out into the surrounding country, was originally a home industry. With the introduction of the power loom came the tendency to concentrate in larger and larger factories, employing up to 500 to 600 looms, the labor, chiefly women and girls, in some cases being brought from a distance and housed in dormitories. Today an interesting retrogression is being witnessed.

The war called the women to the land; and subsequent progress in agriculture has generally improved the status of the peasantry, who do not take kindly to the earlier conditions. The larger mills are being broken up into smaller factories employing from 10 to 25 looms, while there is a growing tendency to the installation of two or three looms in the home on which the family works when agricultural labors permit. The flexibility in the use of hydro-electric power and the well developed power-distribution net make this feasible.

In the earlier days of the industry before much advance had been made in power transmission the electro-chemical and electro-metallurgical industries were installed in the heart of the Alps, close to the power sources; and there most of them remain. The labor problem is met by importation of foreigners, chiefly Italians. In the Maurienne valley, for instance, 70 to 80 per cent of the workers come from Italy. A considerable percentage is seasonal. At least a quarter of the workers return for from three to five months during the winter season of low water and reduced power supply. In this industry too, however, the present tendency is to install new plants on the edges of the mountains, nearer transportation routes and a denser population

Natural Preserves and Natural Parks in Fenno-Scandia. We in the United States become so thoroughly absorbed in the development of our own domain that we are sometimes almost startled when we learn of a diminutive country's ambition to accomplish ends usually construed by us as more or less the exclusive privilege of large and affluent lands. However, the political divisions of Fenno-Scandia entertain no such ideas, as is indicated, for instance, in their national parks policy. While they conceive something of the utilitarian in these preserves by way of their likely attraction of tourists, a view no different from our own, yet pride in their country and enthusiasm for the preservation of natural plant and animal habitats has had no less influence.

Finland has surveyed ten areas, nine in the northern third of the country and one in the southeast corner northeast of Lake Ladoga, which it proposes to set aside as preserves or parks. Recommendations of the reconnaissance parties are not identical in each instance, hence the use of the terminology preserves and parks. In some cases a preserve is suggested because of the desirability of protecting certain species of plants or animals, while in other cases conservation of scenery is paramount, and plants and animals are to receive incidental protection.

The struggle of the scant population of northern Finland is recognized by provisions that, in times of crop failures, proposed restrictions may be temporarily waived in their behalf and that at all times certain hunting and fishing privileges be assigned to them, restricted only by seasonal influences upon the life or variations in rate of reproduction. In these regulations we observe a striking contrast with those applying to most of our own natural parks problems. The wealth of the United States does not necessitate laws modified in favor of a struggling population.

Two papers in the publication "Silva Fennica" of the Society of Forestry in Finland, No. 1, 1926, and No. 3, 1927, present interesting detailed scientific accounts of these regions, accompanied by photographs of characteristic scenes.

What has been noted about the natural park movement in Finland applies likewise to Norway, which proposes parks or preserves for parts of Spitsbergen. There animal life represents a large economic resource, and through the medium of regula-

tion and preserves it is hoped that greater control of animals such as the walrus, polar bear, reindeer, and others can be effected. Problem and plans are given in detail in a bulletin entitled "Naturfredning i Norge," Årsberetning, 1926. An abstract of this paper appears in English in the *Norwegian Trade Review* (Vol. 10, 1927, No. 1, pp. 5–12), and it has been discussed by Dr. R. N. Rudmose Brown in a recent number of the *Scottish Geographical Magazine* (May, 1927).

Since 1909 Sweden has set aside 13 national parks of a total area of 3650 square kilometers and thus possesses the most important series of reservations in Europe. Setting aside of other areas is under consideration. The parks are distributed from the southern end of the country to the northern; and they thus represent practically all aspects of Swedish nature, though above all its harsh but magnificent subarctic and arctic phases, since all the large parks lie in Norrland, the largest within the Arctic Circle. An attractive booklet on the parks has been published by Dr. C. J. Anrick, secretary of the Swedish Touring Club, "Våra svenska nationalparker" (Stockholm, 1927).

EUGENE VAN CLEEF

AFRICA

The Port of Alexandria. Alexandria now occupies third place among Mediterranean ports. In the volume and value of goods handled it is surpassed only by Genoa and Marseilles. Its phenomenal development since the British occupation of Egypt in 1882 has been a response to the increasing prosperity and growing population of Egypt as a whole. A valuable study by Alessandro Breccia of the port of Alexandria was published last year in Italian as Volume 14 of the *Mémoires de la Société Royale de Géographie d'Égypte*. Breccia gives a historical sketch followed by chapters on the technical facilities of the port at the present time, on its commercial relations, on its defects, and on its needed improvements.

The present population of Egypt is about 13,800,000. It is estimated that when certain cultivable, but at present unused, lands in the lower Nile valley and especially in the delta have been reclaimed and occupied the population could be increased to 17,500,000. Furthermore, the maximum density of population which the Egyptian fields are capable of supporting has probably not yet been reached. In 1924 Prince Omar Tussun calculated that in thirty years a total population of about 21,000,000 might be looked for. The probable future increase, whether or not these figures are correct, will mean a corresponding expansion of the trade of Alexandria, a growth that will render extensive improvements in the harbor facilities absolutely imperative. Although the water surface for anchorage is greater at Alexandria than at either Genoa or Marseilles, the improved water front is too short and the railway facilities are inadequate and inconvenient along the quays and wharves. The most serious hindrance to normal growth lies in the present condition of the Mahmudieh Canal, Alexandria's main line of water communication with the Nile and thus with Cairo and the interior of the country as a whole. This canal, constructed by Mahomet Ali in 1819 and the following years, is now too narrow, too shallow, and too much encumbered with "parasite constructions and obstacles of all sorts" adequately to care for the full volume of traffic that should pass through it. It sometimes takes as much as five weeks for a loaded barge to travel the 130 odd miles from Alexandria to Cairo.

Those who have her interests at heart are troubled by the fact that Egypt is becoming a land of one crop. In 1925 the total value of Egyptian exports was £E 59,198,662, of which textile products (mainly cotton) amounted to £E 52,024,761. Egypt is subject to all the economic dangers that menace a region whose prosperity is based upon monoculture. One means of avoiding these dangers is the stimulating of industrial enterprises of all sorts. If present plans for the establishment of manufacturing on a considerable scale are ever brought to fruition, even greater demands will be placed on the port of Alexandria.

In this general connection we may refer to two important recent works on Egypt, both by former students of eminent geographers. In "Ewiges Stromland: Land und Mensch in Agypten" (Stuttgart, 1926), Alfred Kaufmann, who studied under Alfred Hettner and who for some years was director of the German School in Alexandria, has "laid particular emphasis upon the close connections between man and land and upon the development of culture as circumscribed by the natural limitations of the land." Henri Lorin, author of the broad survey entitled "L'Égypte d'aujourd'hui: Le pays et les hommes" (Cairo, 1926), was a pupil of the late Paul Vidal de la Blache. His book is divided into four sections, dealing in order with the physical, regional, economic, and political geography of Egypt.

Natal as a Source of Tanning Material. "For some time past the question of future supplies of vegetable tanning material has been a matter of some anxiety in the leather industry, not only of the United Kingdom but throughout the world." The Imperial Institute has taken up the question as regards the United Kingdom which, it is pointed out, derives more than half its requirements from without the Empire, the most important single source being Argentine quebracho. In its *Bulletin* the Institute is publishing a review of the situation—the October, 1927, number being devoted to the barks, chief of which is the wattle. Geographical interest lies primarily in the successful transplanting of the industry.

In 1880 the tannin-producing wattle, indigenous to Australia, was introduced into South Africa, where its cultivation has been so greatly extended, particularly in Natal, that it has given rise to one of the chief industries of the country. A suitable climate, a plentiful supply of cheap labor, and a local market for the wood as mine props and fuel have been the encouraging factors. Other parts of the Empire where the industry is proving successful are the highlands of Kenya Colony and the hills of southern India, in both of which areas natural conditions are highly favorable.

On the other hand Australia, once the only commercial source of the bark, has insufficient for domestic consumption and imports it from Natal. The Australian industry has been dependent on the natural forests, and those favorably situated for exploitation have been depleted by general destruction of the trees.

AUSTRALASIA AND OCEANIA

Land Utilization in Hawaii. In "The Economic Geography of Hawaii" (*Univ. of Hawaii Research Publ. No. 2.*), Otis Willard Freeman discusses the highly specialized types of land utilization which exist in the Hawaiian Islands. Although the total land area of the islands is less than that of New Jersey and only 10 per cent of it is under cultivation, the annual agricultural exports of Hawaii amount to about $110,000,000, a per capita value of nearly $400.

Similarities in origin and in geological history make it possible to distinguish corresponding physiographic regions on all the islands. These regions are, in turn: the beaches; the coastal plains, deltas, and alluvial slopes; the recent volcanic flows and flow margins; the older sloping flow surfaces; and the mountain tops which may form flat swampy plateaus, narrow serrated ridges, or high treeless domes. In general, each physiographic zone is characterized by a particular utilization of the land. The zones, however, are seldom continuous, nor is the utilization of them complete.

The beach zone consists of raised coral reefs and sand dunes. Here the chief activity is fishing; the Hawaiians have augmented their natural fish supply by constructing many fish ponds in the shallow waters along the shore.

The coastal plains, deltas, alluvial slopes, and valley floors are flat and easily drained or irrigated. Rice, cultivated by hand in fields too small for the use of modern machinery, is the main crop. Although two crops can be grown each year, poor

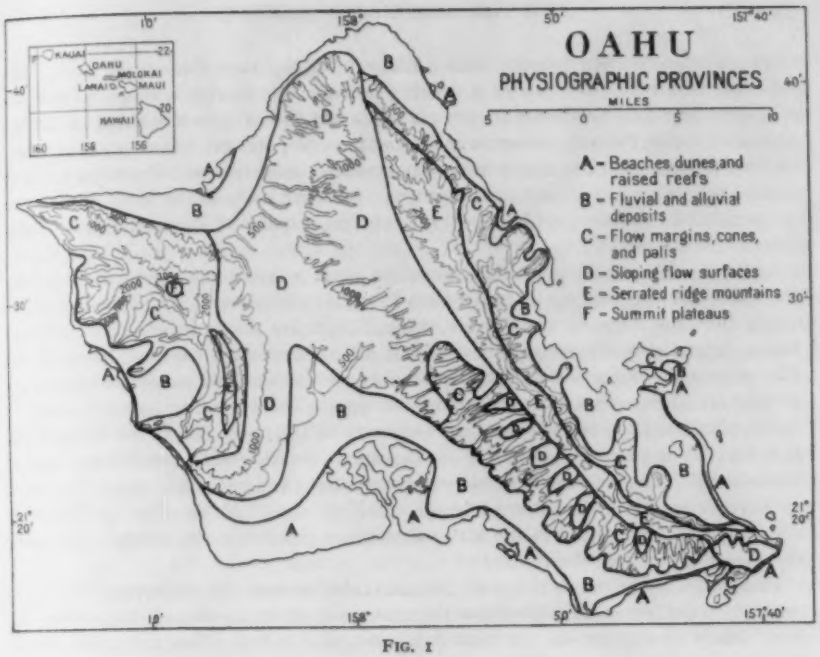


FIG. 1

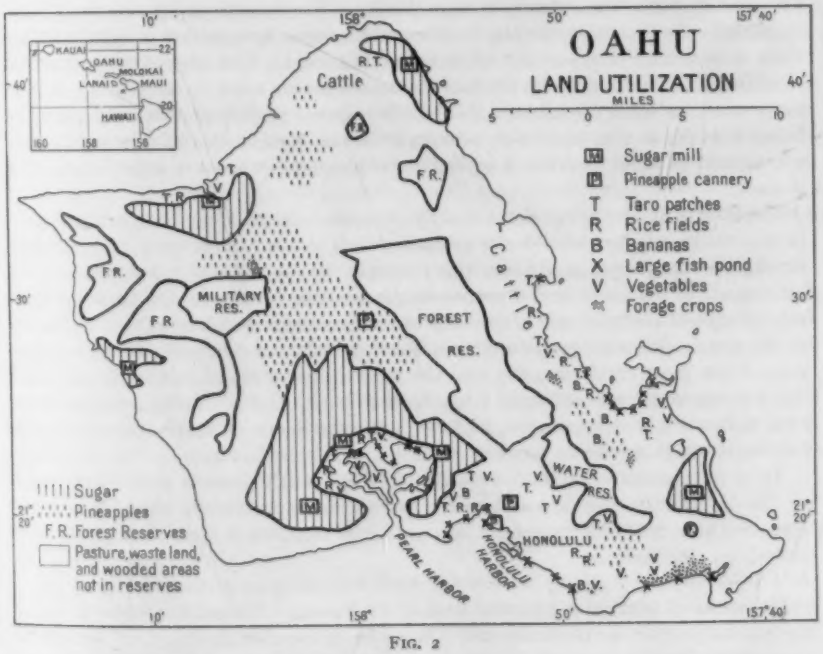


FIG. 2

FIGS. 1 and 2—Sketch maps of the island of Oahu to illustrate the close correlation between the types of land utilization and physiography. Scale approximately 1:630,000. Redrawn from Freeman's Figures 2 and 15.

methods of cultivation coupled with a distaste for the local rice on the part of the Japanese residents have caused a decided decrease in the rice acreage. Taro, one of the greatest food producers per acre in the world, is also grown in this zone. Taro does not exhaust the soil, is easy to raise, and has few parasites. Here, too, are found Chinese bananas, fifth in importance among Hawaiian exports. There are no large banana plantations; and lack of coöperation, competition with the West Indies, and the perishability of the fruit have retarded the exploitation of this crop. Some sugar cane is also raised.

Sugar cane, the most important Hawaiian crop, is dominant on the old flow surfaces and on the gentle slopes below 1200 ft. Over the greater part of the low plains where the cane is grown the rainfall is insufficient for the demands made upon it. Hence irrigation with its attendant ditching, piping, and tunneling must be employed. The perishable characteristics of the cane as well as its bulk make it imperative to convert the cane into raw sugar on the spot. The Hawaiian sugar industry is favored by good soil and climate, the longevity of the cane, liberal use of fertilizer, sufficient labor supply, progressive management, local coöperation and the United States tariff. The increase in production in the last twenty years is due not so much to increase in area in cane as to larger yield per acre. Although suitable land is still available, limitations in the water supply are becoming a determining factor in the future growth of the industry.

Pineapples are grown in the same physiographic zone as the sugar cane but on the rough land and steep hillsides above the cane fields up to an elevation of about 2200 feet. Since pineapples do not need irrigation, this industry has expanded, not at the expense of sugar cane, but of pasture and waste land. The virtual monopoly of the canned pineapple industry which the Hawaiian Islands enjoy has been made possible by the favorable climate, by the use of land better suited to pineapple culture than to anything else, and by scientific management. The employment of special machinery, utilization of by-products, sufficient local capital, advertising, and an early start have all contributed to the phenomenal growth of this industry. Not being as bulky as the sugar cane, pineapples are shipped to central canneries whence the canned product provides freight to the mainland whenever sugar exportation is slack.

The flow ends, the newer flows, and the steepest valleys, as well as the upper parts of the volcanoes, are suitable for grazing. This industry is favored by green feed throughout the year, a local demand in excess of the supply, land too rough for crops, an absence of parasites, and a native who is a natural cowboy. On the other hand the ravages of the wild goats, the lack of water in some localities, the poor quality of the cattle, and some introduced injurious plants are handicaps. There are, however, a few great cattle ranches, and the possibilities of expansion are large. Most dairy products are still imported from the mainland. Coffee culture is an important local utilization of steep, rough lava flows, and coffee is one of the few Hawaiian crops cultivated by independent farmers.

There is no commercial lumbering on the islands at the present time. The forests on the flat swampy plateaus and on the narrow ridges are chiefly valuable for water conservation. For this important purpose forest reserves of more than 96,000 acres have been established.

Estimates of Marine and Fluvial Erosion in Hawaii. The relative rates of erosion by marine and subaerial forces will always be of interest to those who recall the controversy over peneplains and plains of marine denudation. But though the fires of this controversy have fortunately died down, it must be admitted that the proof of the greater effectiveness of erosion by subaerial forces has rested on general argument rather than quantitative proof. C. K. Wentworth has taken advantage of the new topographic maps of the Hawaiian Islands, issued by the U. S. Geological Survey,

and of his own residence of a year in the Islands, to give us some computations (*Journ. of Geol.*, Vol. 35, 1927, pp. 117–133). A restoration of the original symmetrical flow slopes of the volcanoes was first made, and the volumetric departures of the present surface from this ideal form were computed. Restoration of flow slopes and calculation of the volume eroded were carried on many years ago by H. H. Robinson in his study of the San Francisco Volcanic Field, Arizona (*U. S. Geol. Survey Professional Paper 76*, 1913, pp. 49–51 *et al.*). Robinson expressed the volume eroded in per cent of the total volume of the cone. Wentworth presents his figures in mile feet (1 foot deep over a square mile) or in depth of removal over the area in feet. Marine erosion has also been computed by systematic measurements of the cliff height to determine mean height. This quantity is the base of a triangle whose other two sides are the extension of the slope of the volcanic cone and the submarine profile. The area of this triangle multiplied by the length of coast gives the volume.

Obviously on comparing the results of these calculations the assumption is made, as pointed out by Wentworth, that fluvial and marine erosion began together on the completed slopes of the volcanic cones. H. T. Stearns, in a forthcoming report on the Kau district of Hawaii, has demonstrated that early valleys of large size have been filled with later flows. H. S. Palmer (The Geology of the Honolulu Artesian System, Appendix to Rept. Honolulu Sewer and Water Commission for 1927, Fig. 13) has contoured from well records the surface of the basalt under the cover of the Honolulu coastal plain. Here valleys coincident in position with the subaerial valleys of the mountains back of the city extend for 1000 to 1300 feet below sea level. Thus a former elevated position of the land is demonstrated. In general, however, Wentworth's assumption appears to be correct. The present cycles of erosion, fluvial and marine, began simultaneously on completion of the volcanic cones.

Using figures for selected areas, Wentworth shows that for a large part of the erosion cycle the quantity of material removed by fluvial action increases at a rate midway between the first and second power of the quantity removed by marine erosion. For the islands as a whole (Table VII) the quantity of fluvial erosion is seven times that of marine erosion. Thus even in the stormy seas of the mid-Pacific, subaerial erosion is much more effective than marine erosion. On the average continental coast the effectiveness of waves is doubtless proportionably lower.

The attempt to use the quantities of material removed by fluvial erosion as a measure of the age of the islands in years appears to be less happy. Obviously any errors in the basic assumption of a single cycle of erosion are here magnified, whereas in the comparison of rates it may be supposed, for lack of specific knowledge, that the quantities of fluvial and marine erosion obtained in the calculations may be more or less equally affected by partial cycles of erosion induced by uplift, depression, or renewed outpourings of lava.

The advantage of these quantitative studies lies, however, not only in the successes but also in the failures or partial failures. The rigid analysis required by mathematical expression makes evident the gaps in our knowledge and leads to renewed effort to accumulate facts.

KIRK BRYAN

GEOGRAPHICAL NEWS

An Announcement Regarding the New Journal of Abstracts in the Social Sciences. The Social Science Research Council announces plans to establish a Journal of Abstracts in the Social Sciences. These plans are the result of five years study by a committee of the Council which has canvassed the situation with respect to the needs, resources, and purposes to be served by a comprehensive abstract service in the Social Sciences.

A substantial subsidy, a sum of $500,000, available over a period of ten years, has been provided by the Laura Spelman Rockefeller Memorial.

In its report to the Council at Hanover, N. H., in August, 1927, the Committee on Social Science Abstracts stated the need for abstracts in the following paragraphs.

"The founding of the Social Science Research Council is itself a recognition of the fact that leaders in the social sciences are convinced that research in these disciplines is greatly in need of stimulation and direction and, further, that the scholars in these fields should be brought closer together for the consideration and solution of common problems. On the other hand, the deliberations of the Committee on Social Science Abstracts, and much of the information gathered by it, clearly bring out the fact that one great obstacle to the doing of truly scientific research in these fields lies in the tremendous mass of the materials to be considered and in the relative, if not quite complete, lack of appropriate tools for attacking it. There are so many books, pamphlets, and reports constantly being published and so many periodicals both scientific and semi-scientific steadily pouring from the printing houses both here and abroad, that it is physically impossible for any one to keep abreast of all the literature even in his own special field of work. For this reason, also, and in making a courageous effort to read what he should, he is likely to take first the publications obviously in his own special field and, for lack of time to do more, to become increasingly oblivious of what is being done in other disciplines upon the same subjects. Thus artificial departmental lines tend to become sharper, and in his mind the social sciences stand as distinct and separate fields.

"To overcome these difficulties, a journal is proposed which will save an almost infinite amount of time and labor on the part of research workers, by giving them in one journal complete citations and short but objective abstracts of all important new materials, and will at the same time draw together the several disciplines by serving them all through one journal based upon some systematic classification and improved by numerous cross references to the materials in other fields. Other important advantages of such a publication could easily be stated. It will save much duplication and waste of effort, it will appraise the worker of the existence of other specialists working on his problems and stimulate correspondence between them, it will call attention to new methods of research, it will serve as a permanent record of the work already accomplished, and will in many other ways promote the healthy development of the sciences to which it relates."

The Social Science Research Council has appointed an Organizing Committee consisting of the following scholars and charged with the responsibility of organizing and establishing *Social Science Abstracts:* Dr. Isaiah Bowman, American Geographical Society; Dr. Davis R. Dewey, Editor of the American Economic Review; Dr. Carlton Hayes, Professor of History, Columbia University; Dr. Frederic A. Ogg, Editor of the American Political Science Review; Dr. Frank A. Ross, Editor of the Journal of the American Statistical Association; Dr. Clark Wissler, Professor of Anthropology, Yale University; and Dr. F. Stuart Chapin, chairman, Professor of Sociology, University of Minnesota.

To assist the Organizing Committee a number of advisory committees have been appointed in the fields of cultural anthropology, economics, history, human geography, political science, sociology, and statistics. These advisory committees have been asked to suggest: (1) the names of scholars who may be considered for the positions of salaried editors and unsalaried consulting editors; (2) to draw up a scheme of classification adequate to the needs of the systematic grouping of materials from their respective fields of specialization within the social sciences.

Since the Council is made up of delegates from the national learned societies in the fields of anthropology, economics, history, political science, psychology, sociology, and statistics, the purposes of the Council in its efforts to further coöperative scientific research in the social sciences are best served by devoting *Social Science Abstracts* to the fields of cultural anthropology, history, human geography, political science, sociology, and statistics, broadly construed.

Social Science Abstracts will be issued monthly during the year, and in each issue will appear systematic abstracts of new information published in the fields indicated for the preceding month or months. *Social Science Abstracts* will be printed in English in this country, but it will attempt to cover the social science literature of the world as originally published in all languages.

Negotiations are under way to establish a satisfactory basis of coöperation with the Committee on Intellectual Coöperation of the League of Nations in working out a *modus operandi* with the arrangements for economic abstracts undertaken by this international organization.

The test of published materials to be abstracted will in general be the criterion of new information, in the sense of important factual studies and contributions to theory and opinion, in the fields of the social sciences indicated. This will require the careful scrutiny of articles in periodicals, pamphlets, bulletins, monographs, and new books. It is conservatively estimated that the annual number of abstracts will run to fifteen or twenty thousand titles the first year. The abstracts will be cross referred, and annual indexes will be published. It is hoped that the first number of *Social Science Abstracts* may be published within the present calendar year.

F. Stuart Chapin,
Chairman of the Organizing Committee

OBITUARY

Major General George Washington Goethals. Major General Goethals died in New York City on January 21, 1928, in the seventieth year of his age. His outstanding achievement in a distinguished military career was an event of very great geographical importance. In the words of the inscription on the Cullum Medal of the American Geographical Society presented to General Goethals in 1917, he, as builder of the Panama Canal, "fulfilled the ancient dream of Gomara of a highway between the Atlantic and the Pacific and thereby transformed forever the geographic relations of the commercial world" (see *Geogr. Rev.*, Vol. 3, 1917, pp. 396–397).

From 1907 to 1914 General Goethals was chief engineer and administrator on the Isthmus of Panama. He was not only an exceptionally able engineer but also a man of remarkable executive ability. Not less notable than the engineering feat is the work in sanitation that has made the Canal Zone a model for tropical countries, transforming it "from a pestilential area of difficult and dangerous travel to a land where the death rate is less than that of some of our large cities" (R. M. Brown: Five Years of the Panama Canal: An Evaluation, *Geogr. Rev.*, Vol. 9, 1919, pp. 191–198). Other problems involved in the establishment of a temperate zone community in the tropics lay in the distance from the seat of home authority and the zone's complete dependence on the outside for supplies. Economic and labor problems and city planning had to be considered. The range of activities is well described in a series of papers by men in charge in the volume "The Panama Canal: An Engineering Treatise" edited by General Goethals (New York, 1916). And not least was the problem of administration, described by General Goethals himself in "Government of the Canal Zone" (Princeton, 1915) as "a novel problem in government."

On the completion of the Canal in 1914 General Goethals was appointed Governor of the Canal Zone, in which capacity he served until 1917, thus perfecting the working arrangements of the undertaking. "There are mountains, but there are also hands; give me the resolve and the task will be accomplished. If determination is not lacking, means will not fail." Gomara's vision had been realized.

GEOGRAPHICAL REVIEWS

Recent Works on the Archeology of Central America

T. A. Joyce. **Report on the Investigations at Lubaantun, British Honduras, in 1926.** Plans, diagrs., ills. *Journ. Anthropol. Inst.*, Vol. 56, 1926, pp. 207–230.

Thomas Gann. **In an Unknown Land.** 263 pp.; map, ills., index. Charles Scribner's Sons, New York, 1924. $5.00. 9 x 6 inches.

Thomas Gann. **Mystery Cities: Exploration and Adventure in Lubaantun.** 252 pp.; ills., index. Charles Scribner's Sons, New York, 1925. $5.00. 9 x 6 inches.

Thomas Gann. **Ancient Cities and Modern Tribes: Exploration and Adventure in Maya Lands.** 256 pp.; map, ills., index. Charles Scribner's Sons, New York, 1926. $5.00. 9 x 6 inches.

Gregory Mason. **Silver Cities of Yucatan.** xvii and 340 pp.; map, ills. G. P. Putnam's Sons, New York and London, 1927. $3.50. 9 x 6 inches.

Tribes and Temples: A Record of the Expedition to Middle America Conducted by the Tulane University of Louisiana in 1925. Vol. 1, v and 237 pp.; maps, ills.; Vol. 2, iv and pp. 239–536; map, ills., bibliogr., index. The Tulane University of Louisiana, New Orleans, 1926, 1927. $15.00. 11 x 8 inches.

Manuel Gamio. **Cultural Evolution in Guatemala and its Geographic and Historic Handicaps,** *Art and Archaeology*, Vol. 22, 1926, pp. 203–221; Vol. 23, 1927, pp. 17–32, 71–78, 129–133.

S. K. Lothrop. **Pottery of Costa Rica and Nicaragua.** Vol. 1, xxvii and 225 pp.; map, ills.; Vol. 2, xviii and pp. 227–529; ills., bibliogr., index. *Contribs. Museum of the Amer. Indian, Heye Foundation*, Vol. 8, 1926, New York. $12.50. 10 x 7 inches.

S. K. Lothrop. **Stone Sculptures from the Finca Arevalo, Guatemala.** Map, ills. *Indian Notes*, Vol. 3, 1926, pp. 147–171.

S. K. Lothrop. **Pottery Types and Their Sequence in El Salvador.** Diagrs., ills., bibliogr. *Indian Notes and Monographs*, Vol. 1, 1927, pp. 165–220.

S. K. Lothrop. **Tulum: An Archaeological Study of the East Coast of Yucatan.** Maps, diagrs., ills., bibliogr., index. *Carnegie Instn. Publ. No. 335*, Washington, 1924.

S. G. Morley. **Investigation in [Middle American] Archaeology.** Ills. *Carnegie Instn. Year Book No. 25 for 1925–1926*, Washington, 1926, pp. 259–286.

A. M. Tozzer. **Time and American Archaeology.** Maps, ills. *Natural History*, Vol. 27, 1927, pp. 210–221.

The archeological exploration of an area falls into two phases. The first is the more or less helter-skelter discovery of sites and objects, with a geographic appraisal of the data gained. The second phase comprises the focusing of the scattered finds into regional groups and the resolution of the relationship between zones into problems of sequence, answerable in part by information of a chronological nature.

This, for example, is the course obtaining in the southwestern United States, the archeological area historically best known in the New World.

In the Maya area, on the other hand, a somewhat paradoxical situation has developed. A more or less absolute chronology exists without a sequential archeology

comparably accurate. This condition arose from the brilliant studies of Goodman, Bowditch, Morley, and Spinden on the Maya calendar, by which the dates inscribed on stelae or buildings may be read to yield a time count not only significant within the area but also reducible into units of Christian chronology. Since outside of the limited homeland area of the Aztec there exists no transliterated calendar system and since the Aztec calendar covers only a very limited period before the Conquest, it will be seen that a time count with a range from at least 96 B. C. to about 650 A. D. in one system and, in another abbreviated form, up to and beyond the occupation of Yucatan by the Spaniards, would attract a concentration of effort by investigators.

Furthermore, the natural conditions of the region—a tropical, comparatively pathless bush, tend to prevent excavation on any scale for the history of material culture. Thus except for Spinden's unequaled memoir on Maya art (1917), which is concerned chiefly with stone carving, we have little or nothing definite on the material culture of the Maya. The minor arts of pottery, weaving, manufacture of stone utensils and ornaments, etc., which form the foundations of an archeology, are unclassified and unappraised for lack of a corpus of material of reliable provenience.

However, the remarkable success in the Southwest of "dirt archeology," i. e. the examination by excavation of stratified sites to find, through changes in the material culture, time sequences and cultural relationships, has led to the adoption of these methods by some of the workers in the Maya area. The relation of man to his environment cannot be envisaged clearly without a conception of the dates of his inventions or the sources of his adaptations.

The difficulties of Maya research are well illustrated by Mr. Mason's readable book, "Silver Cities of Yucatan." Contained in its pages are many data as to conditions for travel by land and sea in the eastern portion of the Yucatan Peninsula. The same sort of information, invaluable to the traveler, is to be found in Dr. Gann's three volumes. His archeological data illustrate lamentably well the lack of correlation between Maya dates and the material encountered in excavation. The greater part of his archeological description is contained more fully in his formal presentation, "The Maya Indians of Southern Yucatan and Northern British Honduras," *Bur. of Amer. Ethnology, Bull. 64*, Smithsonian Instn., Washington, 1918.

"Tribes and Temples" is a most successful combination of scientific information and the intellectually lighter aspects of travel. All workers in the parts of Vera Cruz, Tabasco, and Chiapas traversed by Mr. Frans Blom must owe him an everlasting debt of gratitude for his exact location of ruins, his exhaustive collection of published and unpublished data bearing on the region, and his scientific recording and interpretation of his finds. Once more, however, we feel the tragedy of the situation in Maya archeology: the dates are exact, but the correlation between the time factor and the material culture is vague.

The chief archeological project in the Maya area is that of the Carnegie Institution. Since the work of this institution is, as yet, far from complete and the publications are brief resumés produced on each season's work, it is not possible to comment on final results. The scope and broad conception of the work in hand are well given in the words of the director, Mr. S. G. Morley, "This [Guatemalan] contract, together with the one in force with the Mexican Government, brings under the Institution's purview possibly the three most strategic sites for a comprehensive study of the Maya civilization that can be found. Uaxactun is the oldest city of the Old Empire now known, based upon the evidence of the dated monuments (68 to 630 A. D.). Chichen Itzá [the chief center of the Institution's activities] is the oldest city of the New Empire, and was apparently the second place of any importance to be founded in the Peninsula of Yucatan (531 to 1448 A. D.). Tayasal was the last independent Mayan stronghold, and resisted the Spanish arms for a century and a half after the Conquest of Yucatan (1448 to 1697 A. D.). It has the further intimate connection with one of the other two sites, in that it was founded by the Itzá after the destruction of

Chichen Itzá, thus bringing under the Institution's observation and study 16 continuous centuries of ancient Maya History."

The vastly important zone between the Petén and the Copan region is being covered by the British Museum. Mr. Joyce and his associates are boldly attacking the "dirt archeology" of that portion of the Maya area. The preliminary report gives hopeful indications in that three apparently sequential architectural styles have been discovered. Doubtless in time pottery and stone work will have been correlated with these three types of building. Once more the chronological data are of little avail in a city without monuments. However, in the near future some link may be established between Lubaantun and Uaxactun. The many monuments and the long occupation of the latter may furnish a gauge for the history of southern British Honduras and the Petén through the correlation of its monuments with its culture phases.

In western Guatemala Dr. Gamio, working for the Archaeological Society of Washington, has been able to distinguish transitions between the "Archaic" culture of the Valley of Mexico and that of the western Maya. Later perhaps there will be found an actual superposition of objects which will clarify that aspect of Middle American history before the rise of the Maya tribes into civilized states.

Dr. S. K. Lothrop's "Tulum" covers the results of an exhaustive above-ground study of Tulum and sites adjacent to it along the east coast of the Yucatan Peninsula. By means of a careful observation of changes in architectural detail through additions to buildings, by a casting up of structural features definitely Maya and non-Maya, and by information derived from native myths and Spanish historians, he was able to distinguish five periods. The first is the Colonization Period (433–689 A. D.) based on an Old Empire stela found at Tulum and on native traditions (the books of Chilam Balam) that the region was occupied by Maya. The second is the Dark Ages (689–985 A. D.) of which there are no remains extant. The third is the Period of the League of Mayapan (985–1201 A. D.) in which the cities in western Yucatan rose to splendor; but the east coast buildings of this epoch are scant in number and provincial in style. The fourth is the "Toltec" Period (1201–1485 A. D.), to which belongs the majority of the east coast remains. A final period comprises the decadence through pestilence, famine, and civil war of these eastern cities. This book is one of the first comparative and frankly historical essays on Central American architecture. It sets a standard for the regional studies of sequences in cultural manifestations necessary before the history of a nation's civilization can be evolved.

Dr. Lothrop's "Pottery of Costa Rica and Nicaragua" is an exhaustive study of the distribution and classification of the different styles of pottery found throughout that area. It gives one an aspect of a generalized Highland culture of considerable geographical range and of indeterminate basal affiliations, virtually out of the sphere of Maya influence and nearing Isthmian types and styles. In a short paper on the pottery sequence of Salvador, Lothrop describes the discovery of a simplified form of the Mexican "Archaic" underlying the other cultures and separated from them by a thick layer of volcanic ash. Above this ash layer were bits of Maya-influenced pottery. A third group comprises wares attributable perhaps to the Nahua-speaking Pipil, but it is noteworthy that elements considered hitherto "Archaic" are to be found in this latest pottery. In another short paper Dr. Lothrop discusses some stone carvings found in western Guatemala, where he discovered a type of sculpture demonstrably pre-Maya but relatable to other Highland styles found to the southeast in Costa Rica and northwest in Mexico.

Dr. Tozzer boldly sets the stage for future discussions of New World relationships by bringing together the data known to workers of today. In his paper one sees that it is through work like Dr. Lothrop's that we may most surely reconstruct the past. The growing realization of the importance of the relationships between the Maya and the pre-Maya, and the Maya and the Highland cultures shows the

necessity for scientific excavation as a means of determining these phases. Yet it is equally clear that only through the medium of the Maya calendar may the sequences of civilization in the New World be reduced to units of absolute time. It must also be remembered that many times the number of years covered by the Maya calendar must have elapsed before that time count began to function and that a large portion of New World history must be recorded in terms of sequence, not years.

GEORGE C. VAILLANT

REPRODUCTIONS OF EARLY MAPS

EMERSON D. FITE AND ARCHIBALD FREEMAN. **A Book of Old Maps Delineating American History from the Earliest Days Down to the Close of the Revolutionary War.** xvi and 299 pp., maps, index. Harvard University Press, Cambridge, 1926. 16½ x 11½ inches. $25.00.

ARTHUR L. HUMPHREYS. **Old Decorative Maps and Charts.** With illustrations from engravings in the Macpherson collection, and a catalogue of the atlases, etc., in the collection, by Henry Stevens. viii and 51 and xliii pp., and 79 plates of maps; ills. Halton & Truscott Smith, Ltd., London; Minton, Balch & Co., New York, 1926. $25.00. 12½ x 10 inches.

"A Book of Old Maps" is a scholarly work. The maps reproduced have been carefully selected to illustrate different phases of American history. Unfortunately, however, the reduction of the larger originals is too great to permit of intensive study of their details. Exploration along the coasts of the New World is revealed in a group of world maps; and regional maps show the advance of the pioneers into the interior, the establishment of settlements, and the demarcation of town, county, province, and state boundaries. Military maps display campaigns and battles of the French and Indian Wars and of the Revolution. Town plans help us visualize Boston, New York, and Philadelphia in the Colonial times. Each of the 73 plates is accompanied by several columns of letter press, often entertainingly written and well documented.

There are occasional misleading statements. For example, Ptolemy's "Geography" was hardly "the standard work on geography throughout the Middle Ages," for it was virtually unknown in western Europe until its translation into Latin in the fifteenth century. What is the justification for translating *Sacharuum regno* on the Lenox globe as *Sugar Country*? The name certainly comes from the Sacarum Regio or Region of the Sacae of Ptolemy and other ancient authorities. One is also tempted to wonder whether it might not have been well to explain, in connection with the anonymous world map in the Bibliothèque Nationale, that La Roncière's theory ascribing this map to Columbus has been subjected to severe criticism. The uninitiated might easily suppose from Professor Fite's and Mr. Freeman's text that the theory had been generally accepted. These are minor matters, however, which detract but little from the value of a splendid and thoroughly worth-while publication.

Mr. Humphreys' volume is designed primarily as a guide to the collector of decorative maps. It contains 79 reproductions—some in color—of sheets from editions of Ptolemy and other atlases dating from the sixteenth to the eighteenth centuries. Many of these maps are extraordinarily beautiful. The introductory text relates for the most part to the biographical, cartobibliographical, and technological phases of the history of cartography rather than to its geographical aspects. No attempt is made to describe the individual maps or to interpret the features shown upon them. Henry Stevens supplies as an appendix a useful annotated catalogue of atlases, chart books, etc., in the fine collection of Mr. A. G. H. Macpherson, upon which Mr. Humphreys' volume is based.

It is a pity that such a handsome and superficially attractive book as that of Mr. Humphreys should be marred by lack of precision in the historical introduction.

Ptolemy was not "the first to realise and describe the extent of the surface of the globe" (p. 4); nor is it true that Ptolemy "has preserved for us all that was known of geography in the first centuries of our era" (p. 13); nor did Ptolemy's "Geography" stand "as the highest authority for more than twelve hundred years" (p. 16). Why does Mr. Humphreys say that Ralph Higden's map of the late fourteenth century is the earliest example of a colored map, although earlier examples are reproduced in books which he himself cites? On page 38 Mr. Humphreys laments the decline in the art of map making after the close of the seventeenth century. "As surely as map making became a lucrative business not only did its scientific value decrease but its artistic touches gradually disappeared . . . ". It is quite true that the eighteenth-century atlases are not comparable to the work of Mercator, Ortelius, and Blaeu; but we should be misled were we to gain an impression that the "scientific value" of map making was decreasing just at the time when genuinely accurate methods of triangulation, of determining positions by astronomical means, and of representing relief were being worked out. If not from the decorative, certainly from the scientific, point of view cartography made great strides during the eighteenth century.

Drake's Voyage Around the World

Henry R. Wagner. **Sir Francis Drake's Voyage Around the World: Its Aims and Achievements.** xii and 543 pp.; maps, ills., index. John Howell, San Francisco, Cal., 1926. 11 x 8 inches.

John W. Robertson. **Francis Drake and Other Early Explorers Along the Pacific Coast.** 290 pp.; maps, ills., index. The Grabhorn Press, San Francisco, 1927. 10½ x 7¼ inches.

Sir Francis Drake's Voyage Round the World 1577–1580: Two Contemporary Maps. Printed by order of the Trustees, Sold at the British Museum, and by Bernard Quaritch, Ltd., Oxford University Press and Kegan Paul, Trench, Trubner & Co., Ltd., London, 1927. 13½ x 9¾.

N. M. Penzer, edit. **The World Encompassed and Analogous Contemporary Documents Concerning Sir Francis Drake's Circumnavigation of the World.** With an Appreciation of the Achievement by Sir Richard Carnac Temple. lxv and 237 pp.; maps, ills., index. The Argonaut Press, London, 1926. 10½ x 8 inches.

Stirring exploit that it was, Drake's voyage around the world did not enlarge the horizon of geographical knowledge to any substantial degree. Except in the vicinity of Cape Horn no hitherto unknown waters were traversed, no unknown lands coasted. Spanish or Portuguese sailors had everywhere preceded Drake, and Drake himself made use of Spanish and Portuguese maps. Indeed, however much we may admire the heroism and nautical skill of Drake and his company, if estimated strictly from the geographical point of view his voyage belongs in much the same category as certain of the great feats of mountaineering or of aerial navigation of recent years, the geographical importance of which may easily be exaggerated. Merely to go from one place to another, however sensational or unusual the method of travel, is not in itself a contribution to geography.

Drake's circumnavigation, therefore, was not one of the major events in the history of geography. The four publications under review nevertheless reveal to us something of the status of geographical knowledge in the sixteenth century as a background for the details of "the famous voyage." Our interest in these books centers upon this background. Wagner and Robertson give much space to maps and other geographical matters. Students of the period will also be grateful to the British Museum for the admirable reproductions of two important contemporary maps showing Drake's route: "La Heroike Enterprinse faict par le Signeur Draeck d'avoir

cirquit toute la terre," Antwerp (?), 1581 (?) and the "Vera totius expeditionis nauticae descriptio D. Franc. Draci," etc., Amsterdam (?), 1590 (?).

Wagner's bulky volume embodies the results of prolonged and minute research. Only about half of the 543 pages are devoted to the main part of the text: a narrative and interpretation of the voyage in the light of the English and Spanish materials available. In Part II the sources are critically estimated, and the more essential documents are reprinted and translated. The notes, relegated to the back of the book, are extremely full. Wagner holds that there is no just basis for the theory advanced by Sir Julian Corbett and Mrs. Zelia Nuttall that Drake was primarily a statesman and empire builder, whose purpose was the establishment of an English colony on the west coast of North America. The voyage was undertaken, rather, in the interests of English trade, Drake's object being the establishment of commercial relations with the spice islands. An advantageous agreement completed with the Sultan of Ternate was to be a first step in this direction.

Robertson's volume is truly exquisite from the bookmaker's point of view—and it is correspondingly expensive. After sections on Cortes, on the Indians of California, and on the Jesuit explorations in Lower California and about the Colorado River, the author turns to Drake. An extended analysis is given of the controversies that have been waged about the exact location of Drake's anchorage upon the California coast. Robertson believes it must have been in the vicinity of San Francisco Bay but judiciously refrains from picking out any one place. He holds that neither the elaborate arguments of G. C. Davidson in favor of Drake's Bay (see *Bull. Amer. Geogr. Soc.*, Vol. 40, 1908, pp. 449–469, and *Geogr. Rev.*, Vol. 2, 1916, pp. 373–374) nor those of Wagner in favor of Trinidad, farther north, will stand critical scrutiny. This whole problem—after all, like that of the first landfall of Columbus, one of no great intrinsic historical or scientific importance—has called forth a lavish expenditure of scholarly energy in attempts at its solution.

Mr. Penzer has given us a handsome edition of "The World Encompassed," that embroidered and exaggerated narrative of Drake's voyage based on the journals of Fletcher, the chaplain.

An Economic Factor in the History of Sea Power

R. G. Albion. **Forests and Sea Power: The Timber Problem of the Royal Navy 1652–1862.** xv and 485 pp.; maps, diagr., ills., bibliogr., index. (Harvard Economic Studies, Vol. 29.) Harvard University Press, Cambridge, 1926. $5.00. 9 x 6 inches.

From childhood most of us have known and accepted the obvious fact that Britain's existence has depended upon her sea power; but how many of us have ever asked whence she obtained the materials of which her fleets were built? And how many have reflected that if those materials came from outside the empire, Britain's foreign policy in certain instances must have been determined by the necessity of keeping open the way to those sources of supply? These two points are among the principal topics dealt with in this book.

In the early chapters the reader is introduced to the varieties of wood required in naval construction, and the history of England's diminishing woodlands is recounted. Then comes the *pièce de résistance*. When forced to look abroad for masts, timber, and naval stores, Britain turned to the Baltic, especially to Riga, and on various occasions between 1650 and 1815 she was obliged either to display or to use force in order to prevent the supply from being cut off. Denmark, Sweden, the Netherlands, and Russia—all had to be dealt with on this account sooner or later. Sometimes a display of force was sufficient; sometimes, as at Copenhagen in 1801 and 1807, England gave battle in order to keep the Baltic open.

When the Danes interrupted the Baltic mast supply in 1652, the Navy Commissioners accepted American sticks as a substitute; and for a century and a quarter

thereafter their largest masts, though by no means all their timber, were imported from New England. Systematic conservation of white pine for the navy began with the Massachusetts charter of 1691 and ended (in New England) with the American Revolution. But Britain scorned the white oak of America; and, though the live oak of the southern provinces was actually superior to English oak, she failed to utilize it. Professor Albion attributes England's neglect of the live oak to the fact that the southern colonists had other staples upon which to base their commerce. But this hardly excuses the British Government, and it is heartening to learn that the United States did better in this respect. In 1799 and 1800 our Government purchased two islands off the Georgia coast in order to assure itself of a supply of this invaluable naval timber.

Chapter after chapter of this book brings home to the reader the prejudice and stupidity of the British naval authorities and the rottenness of their administration from the time of Pepys to the time of St. Vincent; and he marvels more than ever that England not only survived every crisis but came out on top. If the outcome had been the reverse, historians would have pointed out that it was the inevitable consequence of a thoroughly corrupt government. Here we have an administration that could hardly have been worse, yet England weathers every storm! And as if inefficiency and graft were not enough to bring about her ruin, Britain had to contend with another internal enemy the "Timber Trust." This monopoly disapproved of the rigid inspection of government purchases instituted in 1801 and refused to supply the navy with timber. The boycott continued even after the resumption of hostilities in 1803. For lack of patriotism the record of the organization is almost beyond belief. In 1804 the Navy Board surrendered to it, and for half a century afterwards the "Timber Trust" frequently dictated its own terms to the Government. Yet Bonaparte was defeated, and the British Empire continued to expand and grow rich. What is the explanation? Can it be that the strength of Britain's enemies was sapped by governments even more rotten than her own? Or is it that Destiny wins in spite of all handicaps?

Students of American colonial history will read with especial interest the chapter entitled "The Broad Arrow in the Colonies." Probably no one has made a more careful and thorough study of this subject than the author. It was not an easy task, for there were many conservation acts and it is doubtful whether even the surveyor general of the King's woods knew precisely how to interpret their overlapping provisions. But Professor Albion appears to have kept his bearings uncommonly well and to have grasped both the intention of the British Government and the methods employed by the surveyor general and his deputies to carry that purpose into execution.

New England antiquarians may be disappointed when they fail to find the name of Captain Thomas Coram in these pages, for locally at least he is credited with having brought about the passage of an early act of Parliament which promoted the exportation of naval stores from America and hence their production in the colonies. But it may well be that Coram was more interested in tar and turpentine than in timber, and that on that account Professor Albion purposely left him out of his narrative. More justifiable would be the objection which an ornithologist might make to the statement (p. 241) that the "Broad Arrow" was shaped like a crow's track. A partridge's track would have been a more accurate description. But these are inconsequential details that are scarcely worth mentioning in a review of so admirable a book as "Forests and Sea Power." The extraordinary amount of research upon which it is based is one of its merits. The structure is carefully planned and suggests that the author has an unusually clear and orderly mind. The actual exposition of the subject is remarkable not only for its lucidity but for the life there is in it. And the author's ability to use the English language in a straightforward manner, that is neither ponderous nor sprightly, is a valuable adjunct to his scholarship and to his enthusiasm.

LAWRENCE S. MAYO

Anthropology of China

S. M. Shirokogoroff. **Anthropology of Northern China.** iv and 127 pp.; maps, diagrs. Extra Vol. 2. Royal Asiatic Soc. (North China Branch), Shanghai, 1923.

S. M. Shirokogoroff. **Who Are the Northern Chinese?** *Journ. North-China Branch of the Royal Asiatic Soc.*, Vol. 55, 1924, pp. 1–13.

S. M. Shirokogoroff. **Anthropology of Eastern China and Kwangtung Province.** vi and 162 pp.; diagrs., bibliogr. Extra Vol. 4. Royal Asiatic Soc. (North China Branch), 1925.

In the monograph "Anthropology of Northern China," Professor Shirokogoroff has embodied the results of his researches in the physical anthropology of eastern Asia between the years 1912 and 1918. The bulk of the material, as the title suggests, is drawn from northern China; but a great deal is brought in, for purposes of comparison, from Manchuria, Korea, and the Maritime Province of Siberia. For his effort, carried out in the face of very great difficulties and discouragements, to base our knowledge of the peoples of eastern Asia upon objective physical measurements instead of the mere subjective impressions of travelers, he deserves no little credit.

Save for what seems needless complexity in some of the numerous tables and diagrams, there is little to criticize on methodological grounds. With the intricacies of anthropometry Professor Shirokogoroff seems thoroughly familiar. But he draws far too sweeping conclusions from what are after all quite inadequate data. In many groups the actual number of individuals whose measurements he records is less than 100. In other respects also our author is inclined to base far-reaching assumptions on too slight evidence. Thus he decides (p. 104) through a process of elimination that in prehistoric times northern China, "somewhere in the basin of the Yellow and Yangtse Rivers," was "the sole possible region of habitation for the Tungus." The corollary to this would be of course that these people have since migrated northward to their present homes. But in point of fact it seems fairly certain that the movement of population in that part of Asia which the author is considering has been throughout from north to south. Chinese civilization, it is true, has spread to a certain extent in the reverse direction; but culture drifts are a very different matter from racial ones and, although often confused with them, are subject to entirely different laws.

Our author's belief in the great antiquity of the domestication of the reindeer also seems unfounded. The probabilities all point to its being a comparatively recent practice, in terms of cultural development, inaugurated by peoples familiar with the use of domestic oxen and horses on the one hand and of dog-drawn sledges on the other. Dr. Berthold Laufer in his paper "The Reindeer and Its Domestication" (*Memoirs Amer. Anthropol. Assn.*, Vol. 4, 1917, pp. 91–147), seems to have demonstrated this point quite conclusively.

Professor Shirokogoroff is quite right in insisting upon the constancy of physical types as opposed to language; he shows that the same group may have adopted Turkic, Mongol, and Tungusic dialects in turn at successive epochs, although undergoing little or no change in bodily characters. He does not, however, adhere with unvarying consistency to his own distinctions; at times, for example, it is difficult to know whether he is thinking of the Tungus as a linguistic stock or as a physical type.

The article "Who Are the Northern Chinese?" is in effect a resumé of the above monograph. The author begins with a historical sketch of the science of physical anthropology. There follows an account of the theory of a "Mongol Race," belief in which as a distinct division of mankind he finds untenable. What is usually regarded as such, he tells us (p. 3), is only "an agglomeration and amalgamation of different anthropological types." The remainder of the paper is mainly devoted to a description of the people of northern China, among whom are distinguished

four types, all differing from one another in stature and in cephalic as well as other indices.

The writer assures us that, although a "Mongol Race" does not exist, it is still possible to "recognize a Chinaman" at once, owing to the presence of certain intangible characteristics which "cannot be registered by anthropometrical instruments" (p. 12). Elusive psychological factors may conceivably be in part responsible for this apparent homogeneity of aspect; but Chinese costume plays a far greater part. Few would have the temerity, unless exceedingly inexperienced, to claim to distinguish infallibly among Chinese, Koreans, and Japanese, for example in Occidental dress.

In the introductory chapter to "Anthropology of Eastern China and Kwangtung Province," Professor Shirokogoroff devotes considerable space to refuting some of his critics and concludes by giving a brief but good summary of the geographical conditions controlling movements of population from northern to southern China. Four chapters on measurements and their interpretation and comparison follow and a last chapter entitled "Anthropological Deductions in the Light of Some Ethnical and Historical Parallels."

The value of this concluding chapter, which should be the most important of all, is impaired by the author's attempt to draw conclusions from a field, that of culture history, with which he is not thoroughly familiar. He seems, for instance, to overestimate the probable cultural and linguistic differences between the ancient peoples of the Yangtze valley and their neighbors to the north, the Chinese proper of the classical period. He also refers more than once (e. g. on pp. 124 *et seq.* and p. 129, n. 3) to Aurousseau's theory that the present-day Annamites are descended from the former inhabitants of southeastern coastal China, who he believes migrated *en masse* to their present homes about the beginning of the historical period. This hypothesis, however, has been stoutly controverted by other scholars and appears to have little to recommend it. The author's pet theory of the "undoubtedly southern origin of the Tungus . . . for whom some room on the continent ought to be found" crops out again on page 134; but this determination of the ancient Tungusic habitat by a simple process of elimination, without more tangible evidence, has not met with wide acceptance.

Speaking generally, in this new work Professor Shirokogoroff, like others who have tried to generalize regarding the peoples of Asia, falls short of his full object. This is due simply to the insufficiency of existing recorded data. We have not as yet a large enough body of authentic and properly coördinated material upon which to base conclusions. His effort, however, is a sincere and praiseworthy one; and when more facts have been assembled, his labor will doubtless prove to have been far from vain.

C. W. Bishop

The Geography of Albania

Herbert Louis. **Albanien: Eine Landeskunde vornehmlich auf Grund eigener Reisen.** viii and 164 pp.; map, ills., bibliogr., index. (*Geogr. Abhandl. herausg. von A. Penck.* Ser. 2, No. 3). J. Engelhorns, Stuttgart, 1927. 9 x 6½ inches.

Dr. Herbert Louis acted as topographer with Ernst Nowack in his geological surveys for the Albanian government and spent the summers of 1923 and 1924 in the field. The work under review is the result of these explorations. The book is well documented; the bibliography of 111 entries, beginning with Leake's book (1814), is a good index to the literature apart from "travel" books. A curious omission, however, is Nowack's paper "A Contribution to the Geography of Albania" published in this journal (Vol. 11, 1921, pp. 503–540).

The first sixty pages consist in an excellent summary of the geography of Albania, in which recorded facts are well selected and concisely explained where explanation

is possible. It forms an interesting and well balanced account; and it may be read and appreciated with the help of a good atlas supplemented by the map contained in the book, which though small (1:2,000,000) is clear and uses the latest material.

In the second part Albania is described district by district; these being grouped into four larger regions: the Albanian lowland, widening southward to beyond the Semeni River; Albanian Epirus; Inner Albania, southern and northern, these last being clearly separated on most geographical grounds by a line from Elbasan to Dibra. This part does not make easy reading. It is very largely concerned with land forms, though other aspects are not neglected; consequently it could be fully appreciated only with the help of a good large-scale map or with good block diagrams. The author gives no diagrams, but a fair sample of the landscapes is shown in the sixteen excellent photographs. The existing Austrian map (1:200,000) is not based on surveys. However, we learn that a new map on the same scale is soon to be expected from Vienna. Again, the reader should have access to a geological map. Indeed, having regard to his text, the author ought to have included one in the book. And this leads to the chief matter for criticism.

On almost every page there are references to the character and age of the rocks and to their structure. There is frequent mention of recent dislocations, warpings, and "transverse disturbances," which are evidently of paramount importance. But neither the nature nor the distribution of these is comprehensively indicated. Much prominence is rightly given to the great through valleys all over the country, from the long and profound canyons like that of the Drin to short defiles, now dry, crossing single anticlinal ridges. These valleys are usually referred to as antecedent or epigenetic; and the reader naturally asks for information as to the drainage systems that made them. The author doubtless felt that pending further research he had better not try to satisfy our curiosity on this point. Near the end of the book (p. 147) he explains his reticence on a still more important matter; it would, however, have been as well to state at the outset that higher Albania is largely made up of great ancient surfaces of denudation of little relief that have been deeply trenched by new drainage systems, but that investigation has not yet proceeded far enough to correlate these surfaces either within Albania or with those of other parts of the Balkan Peninsula.

Dr. Louis has nevertheless performed an important service in the elucidation of the remarkable physiography of Albania by drawing attention to the occurrence and position of such features as these old surfaces, the mature but relict river systems upon them, the elbows of river capture, the through valleys, karst phenomena of various scales and stages, and glacial features, and by giving brief but vivid verbal pictures of each. In regard to the evidences of glaciation, special care has been exercised in noting the altitudes of cirques and moraines. These occur on nearly all the higher ranges. The Pleistocene snow line in Epirus near the coast (in latitude 40°) is placed at about 1800 meters (p. 99), and on the central massif of northern Albania at the same altitude (p. 134). In the latter area a mountain group, the Dyalitsa (east of the confluence of the Black and White Drins), nearly 2500 meters high, shows no clear evidence of glaciation, though elsewhere in the same district evidences are found above 2100 meters. It is suggested that the Dyalitsa has been considerably upheaved since the Ice Age; and the extreme youth of the profound (2000 meters) gorge of the Luma, which bisects the range, seems to support this view (p. 148).

This up-to-date work on the least-known country of Europe is most welcome, and it should be read not merely by those interested particularly in physiography. For the author is very precise and careful in his observations on the influence of climate, exposure, and soil upon the vegetation; and he gives many illustrations of the effects of these and of topography on the distribution and life of the Albanians.

Of the many fragments of human geography presented we may allude to two. First, that in general all plains of considerable size are in the hands of large proprie-

tors, such as the Bey families, and that the landless peasants there are economically and socially in a miserable position (p. 50). Yet such areas are capable of vastly increased production. Secondly, we have a picture of the secluded mountain trough of the upper Matí River—the Matya—as the home of the largest North-Albanian clan (about 24,000), a most independent sept, who play a very active part in national politics. This broad and well protected valley is the kernel of the Albanian Noble party, and feudalism persisted here till recently. Moreover, it is physically predestined for such a rôle. The Matí flows in a trench 200 meters deep, and its many affluents dissect the wide valley floor deeply, leaving plateau fragments to form the sites of numerous strongholds. Villages there are along the less broken fringes. But there is no town, and a centrally placed ford serves as site for a weekly market.

ALAN G. OGILVIE

IN FRENCH AFRICA

D. P. BARROWS. **Berbers and Blacks: Impressions of Morocco, Timbuktu, and the Western Sudan.** The Century Company, New York and London, 1927. $3.00. 8 x 5½ inches.

While the author of this book is a student of political science, his book is chiefly noteworthy for its geographical content. His remarks upon French colonial administration in Algeria and Morocco, interesting and entertaining, are far surpassed by his observations on that part of the French African colonial empire bordering on the North Guinea coast, from Dakar by rail to the head of the Senegal Valley and down the Niger to Timbuktu, thence southeasterly to Bassam on the Ivory Coast. Professor Barrows traveled through a country inhabited by Mohammedans of various racial stocks, thence across the important dividing line between Mohammedans and fetish worshipers in the Sudan, from desert country through grassland and scrub and the edge of the forested belt, and finally through the heavy tropical forest of the coast. Here are geographical changes and human reactions to them of such a degree of interest as to tempt one to write indefinitely of interesting details. The Senegal River as a boundary between Berbers and Blacks, the rough line of the division of the Sudan at Lake Chad with constantly growing contrasts in density of population, mode of living, and political control and organization as one goes respectively east and west of the lake, the description of the bush at the edge of the Sudan as one passes through the zone of transition between grassland and forest, the vivid account of the salt caravans from Timbuktu to the salt mines of Taodéni—these are among the questions discussed with an eye to regional relationships rather than to the purely local details.

One is a little startled by the sentence on page 234: "There seems to be an instinctive movement of humanity toward the equator, away from the cold and toward the sun." While this is no doubt true of white and brown breeds in the part of black Africa which the author visited it would be more correct to say that the movement is in the nature of a minor current. Much larger currents of white stocks have moved progressively northward. The great empires, with their capital cities and commercial centers have had a far more conspicuous northing than the southing of the streams that Barrows describes in the Sudan. Recent southward movements in the Sudan have been accredited by many observers to increasing aridity of the desert border.

The observations in the field of political geography are valuable partly for the light they show upon French methods of administration in the great colonial realm from the Mediterranean to the Gulf of Guinea, and partly for the contrasts afforded in the methods of French and British administration of native peoples. Each makes use in its own way of native culture and social and political organization, the British more indirectly than the French and with more attention to control for trade than

for the purpose of bringing about respect for superior organization, as in the case of the French. In the case of both French and British, economic benefits flow chiefly from the maintenance of public order, the suppression of the slave trade, and the general security of life that is brought about. The author compares French procedure with that of Imperial Rome in method but claims that it is just and beneficent beyond disproof. He concludes: "Nowhere in colonial life have the moral qualities of Europe been given finer emphasis than in the relations here established between the white and black races. The prospects of the Sudan rest entirely in the continuation of this authority." All this is written from the standpoint of superior race and culture and in defense of so-called imperialism; and there is undoubted strength on this side of the argument as well as on the other.

The Strait of Gibraltar

Otto Jessen. **Die Strasse von Gibraltar.** xii and 283 pp., maps, diagrs., ills., index. Dietrich Reimer, Berlin, 1927.

Two currents pass through the Strait of Gibraltar, an upper one flowing east and a lower one flowing west. The influence of the upper current is felt in a relatively lesser percentage of salt in the surface waters throughout the southern half of the Mediterranean almost as far as the Egyptian coast. Conversely, the influence of the lower current is felt in the Atlantic in a somewhat greater salinity of the waters at a depth of about a thousand meters throughout an area stretching as far west as the Azores and north nearly to the coast of Ireland. It is estimated that the upper current carries into the Mediterranean 46,041 cubic kilometers of Atlantic water each year and that the lower current carries out to the ocean 43,279 cubic kilometers of Mediterranean water. Were the sea floor of the Strait to be raised 100 meters, the annual excess of 2762 cubic kilometers passing eastward would be cut off, and in time the Mediterranean would dwindle to a group of salt lakes.

These facts and figures illustrate one of the far-reaching influences of the Strait of Gibraltar. No less significant has been the relation of this passageway to the distribution and movements of plants and animals. Although the Strait admits into the Mediterranean many oceanic animals, there are other marine forms "accustomed to cool depths far from the coast" which either cannot reach the inland sea because of its shallow entrance or are not adapted to survive in its warm waters. There are also forms, particularly among the mollusca, that are restricted to the Mediterranean. The near approach of Spain to the African coast has permitted the spread along the western margins of the Iberian Peninsula of a flora characteristic of Morocco and the Canary Islands. At the Strait two of the main routes of bird migration between Europe and Africa converge. On the other hand, the waterway has presented an almost absolute barrier against the passage of certain European mammals into Africa, and vice versa. No less significant has been the relation of the Strait to the advance of civilizations and the flow of commerce: since the early Paleolithic period it has served now as a bridge for and now as an obstacle in the way of movements of men and goods both north and south and east and west.

Dr. Jessen's scholarly and well-balanced study deals witn the Strait and its adjacent shores not only in these larger relations but also as forming a geographical region of itself. The work is based partly on field investigations carried out in 1922 and 1924. More than half of the text is devoted to what the French conveniently term *géographie naturelle* (physical, plant, and animal geography); the remainder to human geography, much attention being given to the historical background. Dr. A. Schulten has contributed a chapter entitled "Die Säulen des Herakles," in which references and descriptions of the Pillars of Hercules in the works of the ancient geographers and historians are discussed (see *Geogr. Rev.*, Vol. 17, 1927, pp. 505–506).

Two particular points deserve special notice. In regard to the structural relations of the Strait, Jessen concurs with other recent geologists in the opinion that Eduard Suess's theory is no longer tenable. Suess conceived that the lines of Tertiary folding developed in the Betic Cordillera swing in an arc around the westernmost gulf of the Mediterranean (Gulf of Alboran) and are continued in the mountains of the Riff. Jessen, however, shows that the strike of the Tertiary folds on both sides of the Strait is generally northeast-southwest rather than north-south. In his opinion the Betic Cordillera and Riff form the outer margins of one great orographic system, paralleling a sunken core now occupied by the Strait and perhaps continued southwestward under the Atlantic. However, "the meridional trend of the older layers binding the continents together at the Mediterranean end of the Straits and further north and south curving around in the form of an arc, is to be explained by the position of these layers at the western apex of a block that was arched up in late Mesozoic times and that later subsided beneath the sea." The Gulf of Alboran now fills the site of this sunken block, the north-south-trending strata being represented in Jebel Musa and the Rock of Gibraltar. (See, however, the criticism of this view in the *Geogr. Journ.*, Vol. 71, 1928, pp. 79–81.)

The second point of particular interest relates to Gibraltar. Jessen's discussion of the strategic, diplomatic, and commercial significance of Great Britain's crown colony is illuminating. The main value of Gibraltar no longer lies in the defensive strength of the Rock itself but rather in the harbor as a naval base dominating one of the world's most critical passageways. Against modern siege operations from the land Gibraltar would be helpless unle s the British could hold the Spanish side of the Bay of Algeciras. It seems a pi t in a genuinely scientific work of this sort the author has deemed it advisab close his discussion of Gibraltar—and with it the volume as a whole—by sounding a note of hostility to Great Britain.

The Oceanography of the Antarctic

Erich von Drygalski. **Ozean und Antarktis.** Maps, diagrs. (Deutsche Südpolar-Expedition, 1901–1903, Vol. 7, Part V, pp. 387–556.) Walter de Gruyter & Co., Berlin and Leipzig, 1926. 14 x 10½ inches.

K. Hessen. **Gezeiten- und strombeobachtungen auf der Winterstation des "Gauss" 1902–03.** Map, diagrs., ill. (*Ibid.*, pp. 557–602.)

In these two publications, which appear some twenty years after the return of the expedition, the oceanographic results of the German South Polar Expedition in the *Gauss* are discussed in a comprehensive manner. Drygalski's paper consists of four chapters dealing respectively with the soundings, the surface waters, the subsurface waters, and the currents. Note must be made of the admirable arrangement of the paper. Each chapter begins with a discussion of the methods used in making the observations that form the subject matter of the chapter and of the accuracy attained; this is followed by a table listing the observational data; the concluding section is devoted to interpreting the data and relating them to the larger problems of oceanography.

Oceanographic observations—soundings, temperatures, densities, salinities—were made not only in the Antarctic waters but also all along the route of the *Gauss* both to and from its south polar station. In discussing the soundings made Drygalski relates them to the general problem of the relief of the ocean floor. In the discussion of the surface waters, he points out that for the sea the non-periodic variations constitute a more important characteristic then the periodic variations, since the causes of the latter reside within the atmosphere, while the causes of the former lie within the sea itself. He therefore gives tabular values of the non-periodic daily fluctuations observed; and on the basis of these observations he summarizes the characteristics of the circulation in the different oceanic areas traversed—the North Atlantic, South Atlantic, and South Indian.

In contrast to the non-periodic fluctuations which Drygalski emphasizes as characteristic for the surface waters, he stresses, in his discussion of the subsurface waters, the importance of mean values, since fluctuations of all kinds become less and less sharply defined with increasing depth. The involved relation between the upper layer of the water, the bottom layer, and the middle layer are here elucidated. In discussing the currents Drygalski distinguishes between purely surface drifts which vary with the winds and the more deep-seated currents to which subsurface currents belong. A section of this chapter is devoted to the chemical, geological, and biological features of currents, in which the gas content of the waters, the character of the bottom, and the plankton are discussed. A short appendix gives the results of wave observations. While the *Gauss* observations made two decades earlier furnish the quantitative basic data of the paper, the discussion is in the light of recent oceanographic knowledge. The publication therefore not only constitutes a primary source of information for the oceanography of the Antarctic but furnishes at the same time an important contribution to the larger problems of the sea.

Hessen's paper deals with a more restricted field of inquiry, namely, the tidal movements at the *Gauss* winter station in the Antarctic. In February, 1902, the vessel became ice-bound off Posadowsky Bay (lat. 66° S., long. 89½° E.). Beginning in June hourly heights of the tide were observed continuously for a period of six months. During this period a number of current observations were also made. Information with regard to tides and currents in the Antarctic is so very meager that for this reason alone these observations are of importance; but additional interest attaches to them because they were made at some distance from the land. At the point where the *Gauss* became ice-bound the nearest coast is about 60 miles distant and the sea somewhat over 1200 feet in depth.

The tide observations were analyzed both harmonically and non-harmonically. The results show the tide here to be of the mixed type, that is one in which morning and afternoon tides differ considerably. The mean range of the tide was found to be just under two feet, the spring range two and a half feet, and the neap range a little over one foot. The relation of the change in sea level to change in barometric pressure was investigated and found to be as 1:12, which accords very well with the ratio demanded by theory. The current observations are of particular interest in two respects. In the first place they were found to be rotary counterclockwise which strengthens Sverdrup's theory with regard to rotary currents; and in the second place the wind current was found to deviate to the left of the wind, which is in agreement with Ekman's theory of wind-driven currents.

H. A. MARMER

THREE STUDIES OF SETTLEMENTS

MARIA RECKNAGEL. **Die Städte und Märkte des Bayerischen Donaugebiets.** Maps, ills., bibliogr., index. *Mitt. Geogr. Gesell in München*, Vol. 20, 1927, No. 1, pp. 3–118.

EDUARD IMHOF. **Siedelungsgrundriss-Formen und ihre Generalisierung im Kartenbilde.** Maps, ills., bibliogr. *Mitt. Geogr.-Ethnogr. Gesell. Zürich*, Vol. 24, 1923–24, pp. 5–60.

JOSEPH GANTNER. **Die Schweizer Stadt.** 179 pp.; diagr., ills., bibliogr., indexes. R. Piper & Co., Munich, 1925. M. 6. 9 x 6 inches.

These three studies of settlements, chiefly towns, are listed in the above order because the first-named is concerned primarily with the country and the situation of the towns and their functions; the second discusses the form of the town and its representation on the map; the third makes an attempt to get an inkling of the minds that sought satisfaction in the outlines and silhouettes of the historic towns of Switzerland.

The Bavarian Danube basin is a very well marked region of agriculture little modified by industry; it is therefore rather poor in towns of any size but has many little market towns or villages, distant perhaps a dozen kilometers from one another. They tend to be at nodes of communication, and their development seems to belong to the thirteenth and fourteenth centuries, when in this region agriculture was feeling the need of centers of exchange. The town population, even including very small towns, is not more than one-third of the whole, and some of the towns, like Augsburg and Regensburg, increased in size rather because they were connected with long-distance traffic than because of local or even regional needs. In the Württemberg portion of the region the town population is a larger proportion of the whole, and there is more industry. In the Franconian region there is still more industry, and the towns are older with market places formed from a square or large space rather than by a mere street enlargement. In the latter region, too, there are many pygmy cities, the results of an exaggerated fashion of city foundation in the Middle Ages. The result is most beautiful, as all will agree who have seen Rothenburg ob der Tauber or Dinkelsbühl.

The mapping of a town is said by Imhof to need special study in order to bring out the really genetic characters; and those who have studied many maps provided in atlases and guides will enthusiastically agree and may be encouraged to follow his arguments. He illustrates many of his points by examples of city growth along radii, with later filling of the intermediate sectors; and on the whole he chooses his examples well, save that in several cases he might have strengthened and expanded the interest of the study by references to French towns.

Gantner gives us what at first sight is a picture book, but on further study it is seen to be a fruit of much meditation and to need the same accompaniment for its proper appreciation. The author probably sacrifices a good deal by leaving out of consideration almost entirely the history of town life, in order that he may concentrate upon plans as developed by aerial photography and silhouettes such as one gets fine chances of studying in Switzerland; many a traveler will here think of Thun or Basel or of Gantner's beloved Bern. The Roman tradition is exemplified, sometimes from towns founded much later; the regularity-in-irregularity of many a medieval town is studied in examples; and much attention is given to the question of dominance of natural forms, such as hills, or of buildings, such as castles, while the streets and squares and fountains, the walls and gates and castles and churches all get treatment. The pictures are a joy, and if we might single one out it would be No. 64, of Rapperswil, a place of unique interest and romantic beauty of setting.

Gantner is evidently striving to apprehend the medieval mind, that sought satisfaction in a castle-crowned hill or in the setting of a great tower or spire on a height with street vistas up to it. The other writers are more content to set out for us what are fairly ordinary facts. None goes very deep into the idea of the city and the life it represents, and the student who knows France and Italy will be at once impressed with the many contrasts that may be worked out between those lands and Switzerland or Bavaria. The medieval market town of the inner parts of the Paris basin is very different from its German-Swiss cousin; but the clock or bell tower, for example, of many towns around the fringe of that basin is a feature that one very often finds in German Switzerland.

To go deeper into the matter of the town someone must try to weave together the threads of general and regional social history, of town geography, and of regional anthropology; for the characteristics of the people who made or extended the town matter almost as much as the situation in which it grew. It is a great task, but one for a traveling philosopher; and a geographer should try to be one if he can.

H. J. Fleure

CORRESPONDENCE

On the Northern Coast of Foxe Land

In connection with the geographical work of the Putnam Baffin Island Expedition (see *Geogr. Rev.*, Vol. 18, 1928, pp. 1–40) the Society sought to get in communication with Mr. George Dawson Howell, Jr., who made observations for the Carnegie Institution of Washington on the Macmillan Expedition of 1921–1922. In a letter dated November 26, 1927, Mr. Howell writes as follows:

You inquire as to my observations on the country about the following stations of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington occupied by me in 1921–1922:

Station	*Latitude*	*Longitude East of Greenwich*	*Date*
Baffin Island No. 3 (Noovookuok) .	65° 23.9′N.	282° 27′	Jan. 5, 1922
Baffin Island No. 5	65° 24.4′N.	283° 19′	Apr. 4, 1922
Baffin Island No. 6	65° 19.9′N.	284° 16′	Apr. 8, 1922

Station No. 3 (Noovookuok) is about a quarter of a mile inland from the western shore of Fox Land and about four miles south of the northernmost point of Fox Land. Noovookuok (which means Big Needle) is a small, sharply-pointed cape jutting westerly. Four miles north of this station the coast runs in a general east-and-west direction. The elevation of this station is about 40′. The highest elevation on Noovookuok is about 100′, not more. South of here, along the western coast of Fox Land, the country is broken with low hills increasing in elevation as you go inland. This coast, in the winter I was there, was supporting eight families. The country around the Hudson Bay Post at Cape Dorset was supporting many more. The land is pretty well covered with caribou moss and lichen sometimes known as *tripe de roche*. There were very few caribou that winter, but there were tracks of a great many bears and plenty of white foxes.

I found a raised beach about three miles inland at an elevation of about 60′, considerably weathered. From Station No. 3 eastward the land flattens out. Offshore, as far as you could see from the highest elevation, lay the barricade ice, consisting of floes that are let down on the ground by the ebb tide and are milled up by the flood coming in and increasing to tremendous thickness.

The elevation of Station No. 5 was about 5′. Just to the westward were a few little humpy knolls and ridges of rock by the shore perhaps 25′ high at the maximum. At some points along this shore the ice foot ran out about a mile as smooth as a table, evidently left by the last spring tide; but from there out the barricade ice ran to the horizon.

Near Station No. 6 there are some broad low ridges (whose highest elevation I estimate at about 50′) rising to the east and north. This station was my farthest east. From the highest elevation I could see the shore stretching away in the far distance to the north. An Eskimo told me the previous winter that he had been up in the bay beyond as far as Kowalook [Koukjak], the outlet of Lake Netchling [Nettilling] and that the tide in the bottom of the bay came in faster than he was able to run. This sounds like a bore tide, and the indications of the barricade ice miles offshore make the statement plausible.

From Noovookuok to the eastward we saw no signs of bear or caribou. No Eskimos live in this part of the country at all.

Yours very truly,

George D. Howell, Jr.

University of Michigan, Ann Arbor,
December 14, 1927.

To the Editor:

Will you allow me to comment upon a book which is being widely read and which has already been reviewed in the October number of the *Geographical Review*? I refer to Mr. C. E. P. Brooks' "Climate Through the Ages" (Benn, London, 1926).

The main thesis of this book, as announced upon the front page, is that we may regard "genial conditions (of climate) as the normal state of affairs on this our earth, and the glacial periods as episodes disturbing the normal climate for a brief time, as at long intervals a passing cyclone disturbs the peaceful life of a tropical island."

The literature of the subject is given with much appearance of completeness, but, what is most remarkable, with no mention of the fact that the same thesis was promulgated with greater clearness a full sixteen years earlier in a joint paper by David White and F. H. Knowlton, two of the most eminent paleobotanists of our time (David White and F. H. Knowlton: Evidence of Paleobotany as to Geological Climate, *Science*, Vol. 31 (N. S.), 1910, p. 760). In this article the opening statement by White and Knowlton is "Relative uniformity, mildness (probably subtropical in degree), and comparative equability of climate, accompanied by a high humidity have prevailed over the greater part of the earth, extending to, or into, the polar circles during the greater part of geologic times since, at latest, the Middle Paleozoic. This is the regular, the ordinary, the normal, condition."

Dr. Charles Schuchert, a high authority on past climates, as early as 1914 dealt with the same subject from the point of view of past faunas (Charles Schuchert: Climates of Geologic Time, *Carnegie Instn. Publ. No. 192*, pp. 265–298, and *Ann. Rept. Smithsonian Instn. for 1914*, pp. 277–311); in the following year I stressed the relationship of these facts to the glacial anticyclones (*Proc. Second Pan-Amer. Sci. Congr.*, Washington, 1916, Sec. II, Vol. 2, pp. 184–187); and the late Dr. Knowlton in 1919 (Evolution of Geologic Climates, *Bull. Geol. Soc. of America*, Vol. 30, 1919, pp. 499–566) went so far as to say:

"It is perhaps not too much to say that it has now been demonstrated beyond reasonable question that climatic zoning such as we have had since the beginning of the Pleistocene did not obtain in the geologic ages prior to the Pleistocene. I think this statement of conditions is very generally accepted by geologists and paleontologists—in fact, I am at a loss to know how the data available can be otherwise interpreted."

While Knowlton's statement is undoubtedly true as it relates to specialists in his field, it is quite another matter as it relates to the general recognition of the facts and the use of them to modify existing theories built upon the diametrically opposite assumption, or in the making of new theories.

Modern geology has been largely built upon the thesis set up by Lyell that "the present is the key to the past"; but geologists are now beginning to realize that the present is but a brief and extremely abnormal period of earth history and that any attempt to use present rates of denudation or deposition as yardsticks for the measurement of past geologic history can lead only to error. Hence the great importance of a book like that of Brooks which presents the arguments in a forceful way for those who have not concerned themselves with this vastly important question.

Despite his failure to take account of the really important literature of his subject, which must take from him any claim to priority, Brooks has read most intelligently and presented very forcefully the material of those articles which are included in his bibliography. He seems to have a special gift for sifting out the essential as it relates to the problem under consideration.

W. H. Hobbs